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Predicting the 'great' recession and the 'poor' recovery – results from a suite of non-linear models for Romania and the Euro Area

A. A. Gălățescu*

V. Labhard**

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* A. A. Gălățescu, National Bank of Romania, Bucharest (25 Lipscani Street, Bucharest 3, 030031 Romania), anca.galatescu@bnro.ro, corresponding author.

** V. Labhard: European Central Bank, Frankfurt (60640 Frankfurt, Germany), vincent.labhard@ecb.europa.eu.

Contents

Abstract

This paper assesses the predictive performance of a suite of non-linear single-indicator models (SIMs) in forecasting GDP and the main expenditure components for Romania and the Euro Area around the trough of the Great Recession and during the subsequent recovery. It shows that in the case of both entities and both episodes, the non-linear suite would have provided timely signals of the developments ahead, thus giving forecasters additional lead time for their predictions. It shows also that the advantage of a non-linear SIMs, in terms of both the timeliness of the signal and the more general forecast accuracy, would have been particularly large in the case of the Euro Area and the Great Recession.

Keywords: evaluating forecasts, combining forecasts, non-linear time-series models, point forecasts, density forecasts, business cycles, disaggregation.

JEL Classification: E32, E37

1. Introduction

The expected future path of main macroeconomic aggregates is a key element of the information set reviewed by forecasters. In order to support forecasters in real time, analysts have to assess the current state of the economy and to consider large data sets composed mostly of high-frequency indicators. Short-term forecasting of relevant macroeconomic aggregates usually relies on statistical models which can exploit such timely information and can deal with mixed frequencies and ragged edges. And in most cases, short-term forecasting relies on a number of models and some kind of average across models, an approach often referred to as a suite-of-models approach.

The challenge of producing timely short-term forecasts has become even more topical since 2008-2009 when the 'great' recession was reflected in the data published by the official statistical releases only in mid-May 2009. However, in the case of the Euro Area, according to the ex-post assessment by the Euro Area dating committee (announcement of 31 March 2009), the peak prior to, and the onset of, the Great recession had been reached already in 2008 Q1.[1] Such delays are potentially very costly, and especially so in the run-up to major swings in the business cycle such as the downturn of the 'Great Recession', and the subsequent recovery.

Across the Euro Area, the publication schedules are such that for most of the countries National Statistical Institutes (NSIs) release the first estimate of GDP at about 45 days after the end of the quarter and at about 60 days the breakdown according to expenditure and income together with a new vintage of data. However, higher-frequency data become available during the quarter when the GDP data are not yet available, albeit with different delays. Monthly data for surveys and monthly data for financial variables are available at the end of a month for the respective month, while industrial production-related data and retail sales are released at about 40 days after the end of the respective month.

The suite-of-models approach for short-term forecasting has been embraced also by several institutions as a means to better address their forecasting needs. The Bank of England 'suite' includes more than a dozen models and combinations, as described in Kapetanios *et al.* (2008). The Norges Bank extended their 'system for averaging models' also to densities (forecasts and combinations), see, for example, Björnland *et al.* (2012) and Aastveit *et al.* (2014). The Riksbank has also taken the approach of forecast combination, see Andersson and Löf (2007) and Andersson *et al.* (2007).

In the vast majority of cases, the models included in the above model suites are linear. The use of nonlinear models is much less widespread, and often cast as a horse race with standard linear models as benchmarks, as documented by e.g. Marcellino (2008) for the case of the US. While many applied papers question the gains in

[1] See the website of the Euro Area Dating Committee at 'www. http://cepr.org/content/euro-area-business-cycle-dating-committee', last accessed July 21, 2017.

forecast accuracy from using non-linear models, e.g. Ferrara *et al.* (2015), others find improvements that are substantial, e.g. Medeiros *et al.* (2005) for the G7 countries.

As recessions and recoveries, especially large ones, may have been better detected with non-linear models, this paper reviews the performance (in an out-of-sample setting) of a suite of non-linear single-indicator models (SIMs) in forecasting GDP and the main expenditure components ahead of the Great Recession and the subsequent recovery, with particular emphasis on identifying the indicators with the highest information content in a non-linear setting, which therefore may be good candidates for the monitoring of cyclical developments for the purpose of professional forecasting. At the same time, only a few papers have analyzed those episodes, e.g. Mazzi *et al.* (2014), and only a few papers are forecasting the main GDP components, e.g. Bulligan *et al.* (2015).

The model suite employed here is used to provide point and density forecasts for GDP and GDP expenditure components, thus covering both the more traditional approach, focused on a measure of central tendency, and the more modern approach, focused on the probability of different paths or sub sets of paths. The suite is applied to Romania and the Euro Area, which has the advantage of illustrating the potential benefits of using a non-linear model suite both for the case of a single country and the case of the Euro Area as an aggregate.

The paper has three more sections. Section 2 provides background on the model suite and the forecast design, Section 3 presents the results for the ability to detect recessions and upswings and accuracy of point forecasts and density forecasts. Section 4 concludes. The Appendix provides comprehensive detail of the results and the data sets.

2. Model suite and forecast design

2.1. MODEL SUITE

This section provides a brief description of the models included in the suite of non-linear single-indicator models. Two types of models from the nonlinear class of models are chosen, smooth transition autoregressive (STAR) models and Markov-switching (MS) models. The advantage of these types of models is that they allow the parameters to be different in different phases of the business cycle, e.g. in expansions and recessions. In the case of the STAR models, the forecast is generated on the basis of different parameters depending on a threshold, in the case of the MS model, depending on a regime, thus allowing the forecast variable to display different behavior conditional on the state of the economy. These features make the non-linear model class useful for forecasting macroeconomic time series, especially those who may change their dynamics over the business cycle.

2.1.1. Smooth transition autoregressive models

The smooth transition autoregressive model for a univariate time series y_t is given by:

$$y_t = \phi_1^{'} z_t \left(1 - G(s_t;\ \gamma, c)\right) + \phi_2^{'} z_t\ G(s_t;\ \gamma, c) + \varepsilon_t, \tag{1}$$

where $z_t = (w_t^{'}, x_t^{'})^{'}$, is a vector of explanatory variables with $w_t = \left(1, y_{t-1}, \dots, y_{t-p}\right)^{'}$ and $x_t = (1, x_{1t}, \dots, x_{kt})^{'}$ a vector of exogenous variables, $\phi_i = (\phi_1^{'}, \phi_2^{'})^{'}$ is a vector of parameters and $\{\varepsilon_t\}_{t=1}^{T}$ is assumed to have zero mean and finite variance σ^2. Different choices of the transition function $G(s_t;\ \gamma, c)$ give rise to different types of regime-switching behavior. The logistic function

$$G(s_t;\ \gamma, c) = [1 + exp(-\gamma \prod_{i=1}^{K}(s_t - c_i))]^{-1},\ \gamma > 0,\ c_{i-1} \leq\ c_i \tag{2}$$

generates the logistic smooth transition autoregressive model (LSTAR), and the exponential function $G(s_t;\ \gamma, c) = 1 - exp(-\gamma(s_t - c)^2), \gamma > 0$ results in the exponential smooth transition autoregressive model (ESTAR).

The transition variable s_t is usually assumed in practice to be a lagged endogenous variable, that is $s_t = y_{t-d}$ for certain delay parameter $d > 0$. The parameter γ determines the smoothness of the transition from one regime to the other. The threshold parameters c can be interpreted as the thresholds between regimes.

The most common choices for K in the logistic function (2) are K = 1 (we denote the corresponding model by LSTAR1) and K = 2 (LSTAR2). For LSTAR1 model the transition from one regime to another is smooth. The LSTAR2 and the alternative ESTAR models are appropriate in situations where the dynamics of the process is similar at both large and small values of the transition variable and different in the middle.

The modeling cycle for STAR models as outlined by Teräsvirta (1994) consist of a number of steps. The algorithm starts by specifying a linear autoregressive model of order p using an appropriate model selection criterion. Then, the null hypothesis of linearity against the alternative of STAR type nonlinearity is tested. If the linearity is rejected the type of transition function and the transition variable are selected.

The parameters of the STAR model are estimated by minimizing the sum of squares function $S(\gamma, c) = \sum_{t=1}^{T}\left(y_t - F(z_t;\ \theta)\right)^2$, where $F(z_t;\ \theta)$ is the skeleton of the STAR model in equation (1) and $\theta = (\phi_1^{'}, \phi_2^{'}, \gamma, c)$ is the vector of parameters. Under the assumption that the errors ε_t are normally distributed, the nonlinear least squares estimates can be interpreted as quasi maximum likelihood estimates. After the initial parameter values are selected, the estimation of the model is made by a nonlinear optimization procedure. Obtaining the point forecasts h-period ahead would require solving a multidimensional integral, but in principle this can be avoided by using Monte Carlo or bootstrap methods.

For reasons of comparability, for each model in the suite, and for both LSTAR and ESTAR specifications lag one for the autoregressive part and the current value of the indicator as exogenous variables are imposed. The transition variable is also set as the lag two of the dependent variable (namely, $s_t = y_{t-2}$). In order to ensure economic interpretability of the estimated model some constraints are imposed to the parameters (the value of the parameter γ that governs the smoothness of transition between regimes is strictly positive and the value of the threshold parameter c belongs to interval between the 10th to the 90th percentile of the transition variable).

Following Franses *et al.* (2002) the one-step-ahead point forecast can be computed as $\hat{y}_{t+1/t} = F(z_t;\ \hat{\theta}_t)$, where $\hat{\theta}_t$ indicates that the parameters were estimated using the observation up to period t. When the forecast horizon is longer than 1 period, an analytic expression for $\hat{y}_{t+h/t}\ (h > 1)$ is not available. For example, the two-step-ahead point forecast can be computed as

$$\hat{y}_{t+2/t} = \frac{1}{k}\sum_{i=1}^{k} F\left(\hat{z}_{t+2/t}^{(i)};\ \hat{\theta}_t\right) = \frac{1}{k}\sum_{i=1}^{k} F\left(\hat{z}_{t+1/t} + \hat{\varepsilon}_i;\ \hat{\theta}_t\right), \tag{3}$$

where k is some large number corresponding to the number of draws. The values of $\hat{\varepsilon}_i$ in (3) are drawn from the presumed distribution of ε_t or, as an alternative, from the residuals from the estimated model. For reasons of saving computational time, a Monte Carlo approach with 1,000 draws from the standard normal distribution was used.

2.1.2. Markov-switching models

The Markov-switching parameter model for a univariate time series y_t is given by equation (4)

$$y_t = \beta_{s_t}' z_t + \varepsilon_t, \tag{4}$$

where $z_t = (w_t', x_t')'$, is a vector of explanatory variables with $w_t = \left(1, y_{t-1}, \dots, y_{t-p}\right)'$ and $x_t = (1, x_{1t}, \dots, x_{kt})'$ a vector of exogenous variables, β_{s_t} is a vector of parameters, s_t is an unobserved scalar that can take on integer values 1,2, ..., N corresponding to N different possible regimes, with transition probabilities as in equation (5)

$$p_{ij} = Pr(s_{t+1} = j | s_t = i), \text{ for i,j} = 1,2, \dots, \text{N} \tag{5}$$

With the $\{\varepsilon_t\}_{t=1}^{T}$ assumed to be normally and independent distributed with zero mean and variance dependent on the state, $\varepsilon_t | s_t \sim \text{NID}\left(0, \Omega(s_t)\right)$.

Following Hamilton (1994), the transition probabilities are collected in an $(\text{N} \times \text{N})$ matrix P known as the transition matrix

$$\text{P} = \begin{pmatrix} p_{1\,1} & p_{2\,1} & \cdots & p_{N\,1} \\ p_{1\,2} & p_{2\,2} & \cdots & p_{N\,2} \\ & & \cdots & \\ p_{1\,N} & p_{2\,N} & \cdots & p_{N\,N} \end{pmatrix}.$$

Let $Y_t = (y_t', y_{t-1}', \dots, y_1', x_t', x_{t-1}', \dots, x_1')'$ be a vector of all observation up to t, θ be the population parameters in (4) and (5) and $Pr(s_t = j | Y_t; \theta)$ with j = 1,2, ..., N be an inference about the value of s_t based on the data up to time t. These conditional probabilities are collected in an $(\mathrm{N} \times 1)$ vector $\hat{\xi}_{t|t}$. The forecast at time t+1 given observations up to time t is denoted by $\hat{\xi}_{t+1|t} = Pr(s_{t+1} = j|Y_t; \theta)$. If the process is governed by regime $s_t = j$ at time t, the conditional density of y_t is assumed to be given by $f(y_t|s_t = j, z_t, Y_t; \theta)$. These densities are collected in an $(\mathrm{N} \times 1)$ vector η_t.

An application of the expectation maximization (EM) algorithm can be used for finding the maximum likelihood estimates. Given an initial value for $\hat{\xi}_{1|0}$ and an assumed value of the population parameter vector θ, the sequence $\hat{\xi}_{t+1|t}$ with $\mathrm{t} = 1, 2, \ldots, \mathrm{T}$ can be found by iterating on equations (6) and (7),

$$\hat{\xi}_{t+1|t} = P \cdot \hat{\xi}_{t|t}, \tag{6}$$

$$\hat{\xi}_{t|t} = \frac{(\hat{\xi}_{t|t-1} \odot \eta_t)}{1'(\hat{\xi}_{t|t-1} \odot \eta_t)}, \tag{7}$$

where $\odot$ denotes element-by-element multiplication and 1 represents an $(\mathrm{N} \times 1)$ vector all of whose elements are one.

The log likelihood function evaluated at the value of θ from above is calculated as $L(\theta) = \sum_{t=1}^{T} \log f\,(y_t|z_t, Y_{t-1};\ \theta)$, with $f(y_t|z_t, Y_{t-1}; \theta) = 1'(\hat{\xi}_{t|t-1} \odot \eta_t)$. The one-step-ahead point forecast is calculated as in equations (8) and (9)

$$\hat{y}_{t+1/t} = E(y_{t+1}|s_{t+1} = j, Y_t\,;\ \theta)\ \hat{\xi}_{t+1|t}, \text{ with} \tag{8}$$

$$\hat{\xi}_{t+1|t} = P\ \hat{\xi}_{t|t}, \tag{9}$$

where $E(y_{t+1}|s_{t+1} = j, Y_t\,;\ \theta)$ is the forecast of y_{t+1} conditional on $Y_t,\ x_{t+1}$, and s_{t+1}. Equations (8) and (9) can be iterated to obtain multi-period forecasts.

A total of six versions of the Markov-switching model are estimated: (i) a version with switches in the intercept only (Ct), (ii) a version with switches in the indicator's coefficients only (Ind), (iii) a version with switches in the variance only (Var), (iv) a version with switches in the intercept and variance (CtVar), (v) a version with switches in indicator's coefficients and variance (IndVar) and (vi) the general switching model specified in equations (4) and (5) (AllVar). For reasons of comparability, in the case of all six versions of the MS model a number of two regimes is imposed. For each model in the suite lag one is used for the autoregressive part and the current value of the indicator set as exogenous variable. The transition matrix P is initialized with a value of 0.9 for the elements on the diagonal and 0.1 for the off-diagonal elements.

2.2. FORECAST DESIGN

The forecasts are obtained on the basis of data sets for Romania and the Euro Area, constructed in analogy, and consisting of quarterly data for GDP, consumption, gross fixed capital formation, imports and exports and a set of 18 indicators at monthly frequency. Those indicators have been selected without the application, but in the spirit, of statistical procedures aimed at pre-selecting data with a view to producing forecasts from a sparse data set with as little replication of related information as possible, as for example in Caggiano *et al.* (2009). This has the advantage that such a data set can be replicated for almost any entity, but in the context of the suite of non-linear single-indicator models presented here the data set can be extended at the forecaster's discretion where possible.

The monthly indicators cover 4 groups of both hard and soft data: industrial production (7 indicators), survey (5), money (3) and foreign (3). Industrial production related data set contains components and the aggregate data; survey data set comprises data from the DG-ECFIN survey; financial variables include exchange rates and equity prices; foreign data refers to the Euro Area economy indicators in the case of Romania and to the US economy indicators in the case of the Euro Area. Table A.1 in Appendix A and Table B.1 in Appendix B display the full list of series and the transformations applied in the cases of Romania and the Euro Area respectively. The data sample spans from 2000 Q1 to 2016 Q2.

The forecasts (point and density) are evaluated for the entire period from 2008 Q3 to 2016 Q2, as well as the separate periods corresponding to the crisis-related downturn or 'great recession' and the post-crisis upswing (the 'poor recovery'), during 2008 Q3 to 2010 Q2 and the return to more normal times (from 2010 Q3 to 2016 Q2), by means of quasi real-time out-of-sample evaluation. This implies that the data availability pattern that exists in real-time was replicated, and the models were re-estimated at each step using only the information available at the time of each forecast, discarding data points that would not have been available at the time of the forecast. This allows the coefficients change at each iteration. The empirical exercise uses recursive estimation; thus, the first set of parameters was estimated on the period from 2000 Q1 to 2008 Q2 and the last set of parameters is estimated on the period from 2000 Q1 to 2016 Q1.

The aim of the evaluation is to reflect as much as possible the use of the models in professional forecasting practice. For this reason, the analysis is made in quasi real time, based on the vintage of data available as of November 2, 2016 with two snapshots of the data being used per month, one reflecting the data availability mid-month, after the release of industrial production data, and one reflecting the end-month, following the release of the survey and financial market data.

Thus, the mid-month data sets incorporate the industrial production data and retail sales up to two months prior and survey data up to the preceding month, the end-month data sets include the industrial production data and retail sales up to two months ago and survey data up to the current month. Data snapshots are considered 'final' (not 'real time') data sets and this implies that revisions that occur in both monthly and quarterly data are not taken into consideration. The monthly indicators are forecast by univariate autoregressive models. The lag length for each individual indicator is chosen based on SIC criterion (with a maximum number of lags of 13) at each point in time the forecasts are computed.

As regards the timing of the forecasts, the first forecast is computed six months before the quarter and the last forecast is computed one month after the quarter (15 days before the flash GDP is released). This implies that for each quarter a sequence of 20 forecasts is computed: the first 12 are pure forecasts (i.e. for the next quarter(s)), the next 6 are nowcasts (for the same quarter) and the last 2 are backcasts (for the preceding quarter, as long as GDP for that quarter is not yet available). For example, the first forecast for 2009 Q1 is computed mid-July 2008 and the last forecast is computed end-April 2009, the first forecast for 2016 Q2 is computed mid-October 2015 and the last forecast end-July 2016.

2.2.1. Point forecasts

For estimation and forecasting the indicators at monthly frequency were aggregated at quarterly frequency (see e.g. Schumacher, 2016). For each SIM the point forecasts were computed as simple averages over the set of 1,000 forecasts based on the Monte Carlo approach. The point forecasts for each quarter were computed as combinations over the suite of the 18 SIMs-based forecasts. Both the standard equal weights scheme and the time-varying weights based on inverse-mean squared forecast error (MSFE) with a rolling window of 3 quarters were used.

The combined point forecasts for each model type were evaluated in an out-of-sample exercise based on root-mean squared forecast error (RMSFE) criterion. Mean forecast error and mean absolute error criteria are also computed for each single-indicator model and for the four groups of variables, however, the results are not specifically reported in this paper. In order to compare the performance of the different forecasting models an AR(1) univariate regression estimated via OLS was used as a benchmark model for the corresponding component.

2.2.2. Density forecasts

For each model specification in the suite the *h*-step-ahead density forecasts are based on Monte Carlo approach based on 1,000 draws from the standard normal distribution. In order to get the density forecasts for each model type the individual indicator-based densities are combined using the equal weights and the time-varying average log score weights with a rolling window of 3 quarters. This approach is preferred also for reasons of comparability with the point forecast evaluation.

The forecast performance of the densities based on each model type is evaluated in terms of scoring rules (see e.g. Jore *et al.,* 2010). In addition, the probability integral transforms (pits) of the realization of the variable with respect to the forecast densities is used in order to check if the densities are well-calibrated. The pits represent the ex-ante predictive cumulative distribution evaluated at the ex-post actual observation. A density is correctly specified if the pits are uniform, identically and for 1-step-ahead forecasts independently distributed. The densities' calibration was examined following, among others, Hall and Mitchell (2007 and 2009).

By taking the inverse cumulative distribution function of the pits, the tests for uniformity can be considered equivalent to the tests of normality of the transformed pits. To test for normality, the statistics of Anderson-Darling (AD), Kolmogorov-Smirnov (KS) and Jarque-Bera (JB) were employed. The likelihood ratio test proposed by Berkovitz (2001) for normality and independence at the $h=1$ horizon has a chi-square distribution with three degrees of freedom, while for longer horizons it has a chi-square distribution with two degrees of freedom. To test for independence of the pits, the Ljung-Box (LB) test based on the autocorrelation coefficient up to three for 1-step-ahead forecasts was used. For horizons *h* greater than 1, the autocorrelations are tested for lags greater than *h*.

3. Results and discussion

The results and discussion for Romania are in Section 3.1, those for the Euro Area in Section 3.2. In each case, we'll be examining first the ability to detect the 'great' recession and the subsequent 'poor' recovery, in terms of predicting the correct sign of changes in GDP and the components at the trough of the recession and the first quarter of the recovery, before turning to the predictive ability of the suite more generally, in terms of root mean square forecast error (in case of point forecasts), average logarithmic score and diagnostic tests of the transformed pits, in case of density forecasts. The results are presented (and tables with the corresponding results included in the text) primarily for GDP, as this may be the main forecast variable for most forecasters. However, reference is made also (and the corresponding results can be seen in the appendix) for the different expenditure components, as for some of the components the suite provides more timely signals and/or generally more accurate forecasts than for GDP itself.

3.1. ROMANIA

3.3.1. Early detection of 'great' recession and 'poor' recovery (point and density forecasts)

In the case of Romania, the 'great' recession (in GDP) covers the period 2008 Q4 – 2009 Q2, the 'poor' recovery the quarter 2009 Q3 (i.e. only one quarter of positive growth, and not a genuine recovery).

On the basis of the point forecasts, the trough of the recession would have been signaled in the month following the corresponding quarter (April 2009), i.e. 1 month prior to the data published for that quarter by the statistical office (see Table 1), while the positive growth rate in 2009 Q3 would have been signaled already during that quarter (July, August and September 2009), i.e. up to three months prior to the GDP data being published by the statistical office. As far as those two quarters are concerned, therefore, forecasters would have gained lead time relative to the official data release by using the suite of non-linear SIMs.

Table 1. Romania – signals of recession (point forecasts)

Projection for (year)	2008		2009				2010				2011				2012				2013				2014				2015				2016	
Projection for (quarter)	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Forecasts (before Qt)																																
Qt-2, end-M2							1																									
Qt-2, mid-M3							1																									
Qt-2, end-M3							1																									
Qt-1, mid-M1						1																										
Qt-1, end-M1						1																										
Qt-1, mid-M2						1																										
Qt-1, end-M2						1																										
Qt-1, mid-M3						1																										
Qt-1, end-M3						1																										
Nowcasts (in Qt)																																
Qt, mid-M1					1																											
Qt, end-M1					1																											
Qt, mid-M2					1																											
Qt, end-M2					1																											
Qt, mid-M3					1																											
Qt, end-M3					1																											
Backcasts (after Qt)																																
Qt+1, mid-M1			2	2														1														
Qt+1, end-M1			2	2														1														

Notes: Table entries denote the number of consecutive quarters of negative growth predicted by the suite (equal weights); shading in dark grey corresponds to the periods with 2 consecutive quarters of negative growth, the light grey area corresponds to quarters with negative growth rates.

Source: authors' calculations.

Those results are supported by the probability of a negative outcome (for 2009 Q1) and positive outcome (for 2009 Q3) that would have been obtained from point and density forecasts (see Table 2), which would have moved above the 50 percent threshold one month ahead of the official data release. Also the evidence on the GDP components would have helped in the assessment, especially for the positive growth rate in 2009 Q3, as there is a strong signal for positive growth in that quarter especially for imports and exports, at all forecast horizons (see the Appendix Tables A.2.1-2.4). However, the sequence of two successive quarters of negative growth during the renewed recession 2009 Q4 – 2010 Q1, and also the later recession 2011 Q4 – 2012 Q1, would not have been signaled.

Table 2. Romania – signals of negative/positive growth (point/density forecasts)

	Predicted probability of negative growth in 2009 Q1				Predicted probability of positive growth in 2009 Q3		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Jul. (mid)	0.00	0.06	0.07	2009 Jan. (mid)	**1.00**	**0.91**	**0.93**
2008 Jul. (end)	0.00	0.06	0.07	2009 Jan. (end)	**1.00**	**0.91**	**0.93**
2008 Aug. (mid)	0.00	0.06	0.07	2009 Feb. (mid)	**1.00**	**0.78**	**0.91**
2008 Aug. (end)	0.00	0.06	0.07	2009 Feb. (end)	**1.00**	**0.79**	**0.91**
2008 Sep. (mid)	0.00	0.06	0.07	2009 Mar. (mid)	**1.00**	**0.70**	**0.89**
2008 Sep. (end)	0.00	0.06	0.07	2009 Mar. (end)	**1.00**	**0.70**	**0.89**
2008 Oct. (mid)	0.00	0.04	0.06	2009 Apr. (mid)	**1.00**	**0.70**	**0.85**
2008 Oct. (end)	0.00	0.04	0.06	2009 Apr. (end)	**1.00**	**0.69**	**0.84**
2008 Nov. (mid)	0.00	0.05	0.06	2009 May (mid)	**1.00**	**0.75**	**0.86**
2008 Nov. (end)	0.00	0.07	0.06	2009 May (end)	**1.00**	**0.75**	**0.86**
2008 Dec. (mid)	0.00	0.09	0.07	2009 Jun. (mid)	**1.00**	**0.79**	**0.87**
2008 Dec. (end)	0.00	0.09	0.07	2009 Jun. (end)	**1.00**	**0.79**	**0.87**
Nowcasts (in Qt)				Nowcasts (in Qt)			
2009 Jan. (mid)	0.00	0.18	0.15	2009 Jul. (mid)	0.13	0.10	0.16
2009 Jan. (end)	0.00	0.17	0.15	2009 Jul. (end)	0.13	0.10	0.15
2009 Feb. (mid)	0.00	0.22	0.16	2009 Aug. (mid)	0.13	0.11	0.15
2009 Feb. (end)	0.13	0.23	0.17	2009 Aug. (end)	0.13	0.10	0.15
2009 Mar. (mid)	0.13	0.24	0.19	2009 Sep. (mid)	0.13	0.11	0.15
2009 Mar. (end)	0.25	0.24	0.19	2009 Sep. (end)	0.13	0.11	0.15
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Apr. (mid)	**0.75**	**0.91**	**0.70**	2009 Oct. (mid)	**0.88**	**0.73**	**0.73**
2009 Apr. (end)	**0.75**	**0.91**	**0.70**	2009 Oct. (end)	**0.88**	**0.73**	**0.73**

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

3.1.2. Overall predictive ability (point forecasts)

While the predictability of the recession, or the first quarter of negative real GDP growth, may have been the most immediate concern at the time, it is also important to assess the predictive ability of the models more generally. Not surprisingly, and as found in most studies that have looked at this to date, the more general predictive ability (and so the result on what may be the 'best' model) varies across components and forecast horizons. This is the reason that throughout this paper, the focus is on the forecast from the suite, i.e. point or density forecasts were combined across all 8 model specifications, and using both the equal weights and recursive weights (even though the results suggest, as in many papers in the literature, that the two sets of weights produce quite similar forecast accuracy, so that the precise weighting scheme applied may be not as quite important for predictive ability as the combining of forecast as such).

In the case of Romania, the combined point forecasts (density forecast are discussed in section 3.1.3) from the suite of non-linear SIMs generally outperform the respective (linear) benchmark at all forecast horizons (see Table 3, in which bold entries signal that the suite outperforms the AR(1)). There are only a few exceptions (e.g. the 1-quarter-ahead forecasts for GDP, and the 2-quarter-ahead forecasts for investment and imports). As might be expected, the relative RMSFE values in general tend to improve as more information becomes available, both for GDP and the components.

Further, the results from the combined forecasts suggest that perhaps the MS family of models gives slightly superior forecast performance compared to the STAR family of models (see Appendix Tables A.3.1 to A.3.5). As regards the point forecasts, in terms of the RMSFE criterion, computed for the sample from 2008 Q3 to 2016 Q2, the best predictive ability is actually found not for GDP, but for some of the components, notably investment, exports and imports, which are the most volatile components, and therefore those most difficult to predict.

Table 3. Romania – forecast accuracy (point forecasts, relative to AR(1) benchmark)

GDP component	GDP		Consumption		Investment		Imports		Exports	
Weighting	equal	recursive	equal	recursive	equal	recursive	equal	recursive	equal	recursive
Forecasts (before Qt)										
Qt-2, mid-M1	**0.99**	**0.99**	1.00	**0.99**	1.01	1.01	1.01	1.01	1.00	1.00
Qt-2, end-M1	**0.99**	**0.99**	1.00	**0.99**	1.01	1.01	1.01	1.01	**1.00**	**1.00**
Qt-2, mid-M2	**0.99**	**0.99**	1.00	**0.99**	1.01	1.01	1.01	1.01	1.00	**1.00**
Qt-2, end-M2	**0.99**	**0.99**	1.00	**0.99**	1.01	1.01	1.01	1.01	1.00	**1.00**
Qt-2, mid-M3	**0.99**	**0.99**	**1.00**	**0.99**	1.01	1.01	1.01	1.01	1.00	**1.00**
Qt-2, end-M3	**1.00**	**0.99**	**1.00**	**0.99**	1.01	1.01	1.00	1.01	**0.99**	**0.99**
Qt-1, mid-M1	1.04	1.03	**0.97**	**0.96**	1.00	1.00	**0.98**	**0.98**	1.02	1.01
Qt-1, end-M1	1.04	1.03	**0.97**	**0.96**	**1.00**	**1.00**	**0.97**	**0.97**	**1.00**	**1.00**
Qt-1, mid-M2	1.04	1.02	**0.96**	**0.95**	**0.99**	**0.99**	**0.97**	**0.97**	**0.99**	**0.99**
Qt-1, end-M2	1.04	1.03	**0.96**	**0.95**	**0.99**	**0.99**	**0.96**	**0.96**	**0.98**	**0.98**
Qt-1, mid-M3	1.03	1.02	**0.95**	**0.94**	**0.97**	**0.97**	**0.96**	**0.96**	**0.98**	**0.98**
Qt-1, end-M3	1.03	1.02	**0.95**	**0.95**	**0.97**	**0.97**	**0.95**	**0.95**	**0.98**	**0.98**
Nowcasts (in Qt)										
Qt, mid-M1	**0.98**	**0.98**	**0.98**	**0.98**	**0.96**	**0.96**	**0.94**	**0.95**	**0.94**	**0.94**
Qt, end-M1	**0.99**	**0.98**	**0.98**	**0.98**	**0.96**	**0.97**	**0.95**	**0.95**	**0.94**	**0.94**
Qt, mid-M2	**0.99**	**0.98**	**0.98**	**0.98**	**0.96**	**0.96**	**0.95**	**0.95**	**0.94**	**0.94**
Qt, end-M2	**0.99**	**0.98**	**0.98**	**0.98**	**0.96**	**0.96**	**0.94**	**0.94**	**0.93**	**0.93**
Qt, mid-M3	**0.97**	**0.96**	**0.98**	**0.98**	**0.95**	**0.95**	**0.92**	**0.92**	**0.92**	**0.92**
Qt, end-M3	**0.97**	**0.96**	**0.98**	**0.98**	**0.95**	**0.95**	**0.92**	**0.92**	**0.92**	**0.92**
Backcasts (after Qt)										
Qt+1, mid-M1	**0.92**	**0.93**	**0.98**	**0.98**	**0.89**	**0.89**	**0.81**	**0.80**	**0.92**	**0.92**
Qt+1, end-M1	**0.92**	**0.93**	**0.98**	**0.98**	**0.89**	**0.89**	**0.81**	**0.80**	**0.92**	**0.92**

Notes: Table entries are RMSFE average across suite relative to the benchmark AR(1) model for the sequence of 20 forecasts considered for each quarter (see Table 1); bold entries indicate relative RMSFE less than one (cases in which the RMSFE is better for the suite than the AR(1) benchmark); the evaluation sample is 2008 Q3 to 2016 Q2.

Source: authors' calculations.

Next, given some of the results reported already, we take a closer look at forecast performance over two sub-samples, a first one covering the 'great' recession (linked to the global financial crisis) and the subsequent recovery from 2008 Q3 to 2010 Q2, and the other one covering the post-crisis episode (the return to more 'normal' times, from 2010 Q3 up to the end of the evaluation sample in 2016 Q2). The results in Table 4 show that in terms of the relative (to the respective AR(1) benchmark) RMSFE criterion the suite of non-linear SIMs tends to perform better during the crisis (the period most difficult to predict with the more traditional linear models) than the post-crisis period (even though the absolute RMSFE values of the respective AR(1) benchmark are higher for the crisis than the post-crisis period).

Table 4. Romania – forecast accuracy (point forecasts, crisis and post-crisis)

	2008 Q3 – 2010 Q2					2010 Q3 – 2016 Q2				
GDP component	GDP	Consumption	Investment	Imports	Exports	GDP	Consumption	Investment	Imports	Exports
Forecasts (before Qt)										
Qt-2, mid-M1	**0.99**	1.01	**1.01**	**1.00**	1.01	1.02	**0.98**	1.01	1.02	**1.00**
Qt-2, end-M1	**0.99**	1.01	**1.01**	**1.00**	1.01	1.02	**0.98**	1.01	1.02	**1.00**
Qt-2, mid-M2	**0.99**	1.01	**1.01**	**1.01**	1.01	1.02	**0.98**	1.01	1.02	**1.00**
Qt-2, end-M2	**0.99**	1.01	**1.01**	**1.01**	1.01	1.02	**0.98**	1.01	1.01	**1.00**
Qt-2, mid-M3	**0.98**	1.01	**1.01**	**1.01**	1.01	1.03	**0.98**	1.02	1.02	**0.99**
Qt-2, end-M3	**0.99**	1.00	**1.00**	**1.00**	0.99	1.03	**0.98**	1.03	1.01	**0.99**
Qt-1, mid-M1	**1.01**	0.98	**0.99**	**0.97**	1.04	1.14	**0.94**	1.05	1.02	**1.00**
Qt-1, end-M1	**1.02**	0.97	**0.98**	**0.96**	1.00	1.15	**0.95**	1.07	1.03	**1.00**
Qt-1, mid-M2	**1.01**	0.97	**0.96**	**0.95**	**0.99**	1.16	**0.95**	1.07	1.03	1.00
Qt-1, end-M2	**1.02**	0.97	**0.96**	**0.95**	**0.96**	1.14	**0.95**	1.06	1.01	1.00
Qt-1, mid-M3	**1.01**	0.96	**0.94**	**0.94**	**0.96**	1.15	**0.95**	1.06	1.01	0.99
Qt-1, end-M3	**1.01**	0.96	**0.94**	**0.94**	**0.96**	1.14	**0.95**	1.05	0.99	0.99
Nowcasts (in Qt)										
Qt, mid-M1	**0.96**	0.99	**0.94**	**0.93**	**0.90**	1.12	**0.98**	1.03	1.00	0.97
Qt, end-M1	**0.96**	**0.98**	**0.94**	**0.94**	**0.88**	1.13	0.99	1.04	1.00	0.97
Qt, mid-M2	**0.96**	**0.98**	**0.93**	**0.93**	**0.88**	1.14	0.99	1.04	1.00	0.97
Qt, end-M2	**0.96**	**0.98**	**0.93**	**0.93**	**0.87**	1.14	1.01	1.05	1.00	0.96
Qt, mid-M3	**0.95**	**0.97**	**0.92**	**0.91**	**0.86**	1.11	1.00	1.05	0.96	0.95
Qt, end-M3	**0.95**	**0.97**	**0.92**	**0.91**	**0.85**	1.11	1.00	1.05	0.97	0.95
Backcasts (after Qt)										
Qt+1, mid-M1	**0.90**	**0.97**	**0.86**	**0.77**	**0.79**	0.99	1.00	0.97	0.98	0.98
Qt+1, end-M1	**0.90**	**0.97**	**0.86**	**0.77**	**0.79**	0.99	1.00	0.97	0.98	0.98

Notes: Table entries are RMSFE average (equal weights) across suite relative to the benchmark AR(1) model, bold entries indicate cases in which the relative (to an AR(1) process) RMSFE is better in one of the sub-sample as compared to the other one.

Source: authors' calculations.

Another interesting result[2] relates to the indicators most useful for producing point (and density) forecasts. In the case of Romania, the best performance comes from the models including variables from the group of international data and, to a lesser extent, surveys and money, for which the RMSFEs are lowest and, broadly speaking,

[2] The results are available upon request.

for all components and at all forecast horizons. This likely reflects the importance of the international environment and monetary developments in the context of a small open economy.

3.1.3. Overall predictive ability (density forecasts)

Turning to the accuracy of the density forecasts, the first result is that, as for the point forecasts, performance depends on the components and forecast horizon, whether for the density forecast from the individual models or the combined density forecast, which we produced in analogy to the combined point forecasts (and with, alternatively, equal and recursive weights). The values of the relative logarithmic score criterion to the AR(1) benchmark show that the suite of non-linear SIMs performs better across the components than for GDP, with the exception perhaps of consumption and, to some extent also, for exports (see Table 5).

Table 5. Romania – forecast accuracy (density forecasts)

GDP component	GDP		Consumption		Investment		Imports		Exports	
Weights	equal	recursive	equal	recursive	equal	recursive	equal	recursive	EW	RW
Forecasts (before Qt)										
Forecast Qt-2, mid-M1	0.08	0.09	-0.01	-0.01	0.07	0.06	0.07	0.06	-0.01	-0.01
Forecast Qt-2, end-M1	0.08	0.09	-0.01	-0.01	0.07	0.06	0.07	0.06	-0.01	-0.01
Forecast Qt-2, mid-M2	0.08	0.09	-0.01	-0.01	0.07	0.06	0.07	0.06	-0.01	-0.01
Forecast Qt-2, end-M2	0.08	0.09	-0.01	-0.01	0.07	0.06	0.07	0.06	-0.01	-0.01
Forecast Qt-2, mid-M3	0.08	0.09	-0.01	-0.01	0.07	0.06	0.07	0.06	-0.01	-0.01
Forecast Qt-2, end-M3	0.08	0.09	-0.01	-0.01	0.07	0.06	0.07	0.06	-0.01	-0.01
Forecast Qt-1, mid-M1	0.08	0.08	0.00	0.00	0.09	0.09	0.09	0.07	0.00	0.00
Forecast Qt-1, end-M1	0.08	0.08	0.00	-0.01	0.09	0.09	0.09	0.08	0.00	0.00
Forecast Qt-1, mid-M2	0.08	0.08	0.00	-0.01	0.09	0.09	0.09	0.08	0.00	0.00
Forecast Qt-1, end-M2	0.08	0.08	0.00	-0.01	0.09	0.09	0.09	0.08	0.00	0.00
Forecast Qt-1, mid-M3	0.08	0.09	0.00	-0.01	0.09	0.09	0.09	0.08	0.00	0.00
Forecast Qt-1, end-M3	0.08	0.09	0.00	-0.01	0.09	0.09	0.09	0.08	0.00	0.00
Nowcasts (in Qt)										
Nowcast Qt, mid-M1	0.07	0.07	0.00	-0.01	0.09	0.09	0.09	0.08	0.01	0.01
Nowcast Qt, end-M1	0.07	0.07	0.00	-0.01	0.09	0.09	0.09	0.08	0.01	0.01
Nowcast Qt, mid-M2	0.07	0.07	0.00	-0.01	0.09	0.09	0.09	0.08	0.01	0.01
Nowcast Qt, end-M2	0.07	0.08	0.00	-0.01	0.09	0.09	0.09	0.08	0.01	0.01
Nowcast Qt, mid-M3	0.07	0.08	0.00	-0.01	0.09	0.09	0.09	0.08	0.01	0.00
Nowcast Qt, end-M3	0.07	0.08	0.00	-0.01	0.09	0.09	0.09	0.08	0.01	0.00
Backcasts (after Qt)										
Backcast Qt+1, mid-M1	0.04	0.05	-0.01	-0.01	0.07	0.07	0.09	0.07	0.03	0.03
Backcast Qt+1, end-M1	0.04	0.05	-0.01	-0.01	0.07	0.07	0.09	0.07	0.03	0.03

Notes: The tables show the average logarithmic score for the suite for the sequence of 20 forecasts produced for each quarter.
Source: authors' calculations.

As regards the performance of the different model specifications, in the case of the density forecasts the STAR specifications tend to be more accurate, displaying the largest average logarithmic score criterion across almost all components and forecast horizons (the LSTAR specification performs better only for imports, albeit at all horizons). This is in contrast to the results for the point forecasts, where the MS family of models seemed to yield better accuracy than the STAR family. As the RMSFE in the case of the point forecasts, the average logarithmic score tends to increase over the forecast horizon for all models and components, pointing to a slight improvement of accuracy as more information becomes available.

The models producing the density forecasts also seem well-specified. At least for the best model in terms of the average logarithmic score, and regardless of whether the model is used for GDP or one of the components, and for which horizon, normality of the transformed pits is generally not rejected, although results are weaker for consumption, investment and imports, supporting to a degree the idea that those components may be somewhat more difficult to predict with non-linear SIMs (see Tables A.3.1 to A.3.5 in Appendix A). The results show further that densities are centered on the actual values especially for nowcasts and backcasts (when more information is available than for the forecasts).

Independence of the transformed pits could not be rejected at 5 percent significance level for most of GDP and components across model specifications and forecast horizons. Normality and independence (Berkovitz test) of the transformed pits is rejected at 5 percent significance level at all forecast horizons and for all GDP and components, but for exports (and to some extent also for imports).

Also in the case of the density forecasts, the results for the combinations appear to hold independently of how the densities were combined (whether equal or recursive weights), suggesting as in the case of the point forecast that the primary issue is one of combining (vs. not combining) forecasts, and not of choosing the weights, with test pointing to a broadly similar forecasting performance in terms of number of times of occurrence of correctly calibrated densities. This suggests that averaging has a similar effect on the robustness of forecast performance in the case of density forecasts as it has in the case of point forecasts.

3.2. EURO AREA

3.2.1. Early detection of 'great' recession and 'poor' recovery (point and density forecasts)

In the case of the Euro Area, the trough of the 'great' recession in GDP occurred in 2009 Q1, with that recession (linked to the global financial crisis) lasting 2008 Q3 – 2009 Q2. That trough in the case of GDP would have been predicted by most of the models at the end of the preceding quarter (end-December 2008), 4.5 months earlier than the data for 2009 Q1 published by Eurostat (see Table 7). At that point, also the duration of the rest of the recession (2 more quarters) would have been predicted accurately (see Table 6). In fact, as can be seen from that table, even the onset of the recession would have been predicted correctly as of the first month of the first quarter with negative growth rate (2008 Q3).

Table 6. Euro Area – signals of recession/recovery (point forecasts)

Projection for (year)	2008		2009				2010				2011				2012				2013				2014				2015				2016	
Projection for (quarter)	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Forecasts (before Qt)																																
Qt-2, end-M2					2	2	2											2	2	2												
Qt-2, mid-M3					2	2	2											2	2	2												
Qt-2, end-M3					2	2	2											2	2	2												
Qt-1, mid-M1				2	2	2													1		1											
Qt-1, end-M1				2	2	2													1		1											
Qt-1, mid-M2				2	2	2													1		1											
Qt-1, end-M2				2	2	2													1		1											
Qt-1, mid-M3				2	2	2													1		1											
Qt-1, end-M3			2	2	2	2											1		1													
Nowcasts (in Qt)																																
Qt, mid-M1			2	2	2													1		1												
Qt, end-M1		2	2	2	2													1		1												
Qt, mid-M2		2	2	2	2													1		1												
Qt, end-M2		2	2	2	2													1														
Qt, mid-M3		2	2	2	2													1														
Qt, end-M3		2	2	2	2													1														
Backcasts (after Qt)																																
Qt+1, mid-M1	2	2	2	2											2	2	2	2	2	2												
Qt+1, end-M1	2	2	2	2											2	2	2	2	2	2												

Notes: Table entries denote the number of consecutive quarters of negative growth predicted by the suite (equal weights); shading in dark grey corresponds to the periods with 2 consecutive quarters of negative growth, the light grey area corresponds to quarters with negative growth rates.

Source: authors' calculations.

Furthermore (see Tables B.2.1 to B.2.4 in Appendix B), a clear signal would have merged also for the components and, among those, in particular for investment, imports and exports. Overall, for GDP and the components, therefore, the signal from the suite, at least for the downswing, would have been timelier in the case of the Euro Area than Romania, which would suggest that the larger entity is somewhat easier to predict than the smaller one.

Table 7. Euro Area – signals of negative/positive growth (point/density forecasts)

	Predicted probability of negative growth in 2009 Q1				Predicted probability of positive growth in 2009 Q3		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Jul. (mid)	0.00	0.02	0.08	2009 Jan. (mid)	0.38	0.48	**0.56**
2008 Jul. (end)	0.00	0.04	0.10	2009 Jan. (end)	**0.50**	0.49	**0.56**
2008 Aug. (mid)	0.00	0.04	0.10	2009 Feb. (mid)	0.13	0.38	0.20
2008 Aug. (end)	0.00	0.03	0.09	2009 Feb. (end)	0.00	0.34	0.10
2008 Sep. (mid)	0.00	0.03	0.10	2009 Mar. (mid)	0.00	0.32	0.06
2008 Sep. (end)	0.00	0.05	0.11	2009 Mar. (end)	0.00	0.31	0.05
2008 Oct. (mid)	0.00	0.11	0.13	2009 Apr. (mid)	0.00	0.21	0.01
2008 Oct. (end)	0.00	0.39	0.29	2009 Apr. (end)	0.00	0.27	0.02
2008 Nov. (mid)	0.00	0.40	0.31	2009 May (mid)	0.00	0.25	0.02
2008 Nov. (end)	0.13	0.44	0.37	2009 May (end)	0.00	0.29	0.04
2008 Dec. (mid)	0.25	0.48	0.43	2009 Jun. (mid)	0.00	0.31	0.05
2008 Dec. (end)	**0.63**	**0.55**	**0.53**	2009 Jun. (end)	0.00	0.34	0.06
Nowcasts (in Qt)				Nowcasts (in Qt)			
2009 Jan. (mid)	**1.00**	**0.63**	**0.91**	2009 Jul. (mid)	0.00	0.04	0.00
2009 Jan. (end)	**1.00**	**0.65**	**0.91**	2009 Jul. (end)	0.00	0.05	0.00
2009 Feb. (mid)	**1.00**	**0.68**	**0.98**	2009 Aug. (mid)	0.00	0.06	0.00
2009 Feb. (end)	**1.00**	**0.70**	**0.99**	2009 Aug. (end)	0.00	0.06	0.00
2009 Mar. (mid)	**1.00**	**0.72**	**1.00**	2009 Sep. (mid)	0.00	0.07	0.00
2009 Mar. (end)	**1.00**	**0.71**	**1.00**	2009 Sep. (end)	0.00	0.07	0.00
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Apr. (mid)	**1.00**	**0.99**	**1.00**	2009 Oct. (mid)	**1.00**	**0.78**	**0.88**
2009 Apr. (end)	**1.00**	**0.99**	**1.00**	2009 Oct. (end)	**1.00**	**0.78**	**0.87**

Notes: Table entries are measures of the probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

As regards the subsequent recovery, 2009 Q3 – 2011 Q3 in the case of the Euro Area, this is somewhat less obvious though, as the signal would initially have been wrong, i.e. the recession forecast to continue longer than it did in the end, and the signal less timely for GDP, imports and exports than for the other expenditure components, and also less timely for the Euro Area than for Romania (see Tables B.2.1 to B.2.4 in Appendix B). Although it is not the focus here, similar results (albeit fewer signals, both correct and incorrect) are obtained also for the second recession (2011 Q4 – 2013 Q1, connected to the sovereign debt crisis, see again Table 6).

3.2.2. Overall predictive ability (point forecasts)

Also for the Euro Area (as for Romania, as discussed in Section 2, and in the literature to date), the more general predictive ability (and so the result on what may be the 'best' model) varies across the forecast horizons and the target variables. Overall, however, for the Euro Area, the MS models tend to perform better than STAR specifications, across expenditure components and forecast horizons (see Tables B.3.1 to B.3.5 in Appendix B). As expected though, there is no particular specification that dominates at all forecast horizons.

In the case of the Euro Area, the results for the predictive ability of the combined point forecasts, combined across the eight model specifications using, alternatively, equal weights or time-varying weights, are quite remarkable. In terms of the RMSFE criterion, the suite of non-linear SIMs outperforms the AR(1) benchmark for all GDP and components and at all forecast horizons, with considerable gains in predictive ability for GDP, as well as several of the components (investment, imports and exports). In the case of GDP, for example, the gain is at least one third of the RMSFE. As before, it matters little which set of weights is being applied, with equal-weights and recursive-weights combination schemes producing similar results across combinations, across GDP and the components (see Table 8). And as for the timeliness of the signal, we find that the more general accuracy of the point forecasts, as measured by the RMSFE, are much better for the Euro Area than for Romania, especially in the case of GDP.

Table 8. Euro Area – forecast accuracy (of point forecasts, relative to AR(1) benchmark)

GDP component	GDP		Consumption		Investment		Imports		Exports	
Weights	equal	recursive	equal	recursive	equal	recursive	equal	recursive	equal	recursive
Forecasts (before Qt)										
Qt-2, mid-M1	**0.55**	**0.55**	**0.96**	**0.95**	**0.84**	**0.81**	**0.86**	**0.86**	**0.74**	**0.72**
Qt-2, end-M1	**0.53**	**0.53**	**0.95**	**0.94**	**0.82**	**0.79**	**0.84**	**0.84**	**0.71**	**0.70**
Qt-2, mid-M2	**0.54**	**0.53**	**0.95**	**0.94**	**0.82**	**0.79**	**0.85**	**0.85**	**0.72**	**0.71**
Qt-2, end-M2	**0.52**	**0.51**	**0.94**	**0.94**	**0.80**	**0.78**	**0.84**	**0.84**	**0.70**	**0.70**
Qt-2, mid-M3	**0.52**	**0.51**	**0.94**	**0.94**	**0.80**	**0.78**	**0.85**	**0.84**	**0.70**	**0.70**
Qt-2, end-M3	**0.51**	**0.50**	**0.93**	**0.93**	**0.79**	**0.77**	**0.83**	**0.83**	**0.69**	**0.69**
Qt-1, mid-M1	**0.63**	**0.63**	**0.88**	**0.87**	**0.79**	**0.79**	**0.82**	**0.82**	**0.74**	**0.74**
Qt-1, end-M1	**0.60**	**0.60**	**0.85**	**0.84**	**0.76**	**0.76**	**0.77**	**0.76**	**0.70**	**0.69**
Qt-1, mid-M2	**0.60**	**0.60**	**0.85**	**0.84**	**0.75**	**0.75**	**0.75**	**0.74**	**0.69**	**0.69**
Qt-1, end-M2	**0.58**	**0.58**	**0.84**	**0.83**	**0.73**	**0.73**	**0.72**	**0.72**	**0.67**	**0.67**
Qt-1, mid-M3	**0.57**	**0.57**	**0.84**	**0.83**	**0.72**	**0.71**	**0.71**	**0.71**	**0.66**	**0.66**
Qt-1, end-M3	**0.56**	**0.56**	**0.83**	**0.82**	**0.70**	**0.70**	**0.68**	**0.67**	**0.64**	**0.64**
Nowcasts (in Qt)										
Qt, mid-M1	**0.68**	**0.68**	**0.81**	**0.80**	**0.75**	**0.75**	**0.68**	**0.68**	**0.70**	**0.69**
Qt, end-M1	**0.66**	**0.66**	**0.80**	**0.79**	**0.74**	**0.74**	**0.66**	**0.65**	**0.67**	**0.66**
Qt, mid-M2	**0.64**	**0.63**	**0.78**	**0.78**	**0.71**	**0.71**	**0.60**	**0.60**	**0.63**	**0.63**
Qt, end-M2	**0.62**	**0.61**	**0.77**	**0.77**	**0.69**	**0.69**	**0.58**	**0.58**	**0.60**	**0.60**
Qt, mid-M3	**0.60**	**0.60**	**0.76**	**0.76**	**0.68**	**0.68**	**0.55**	**0.55**	**0.58**	**0.58**
Qt, end-M3	**0.60**	**0.59**	**0.75**	**0.75**	**0.68**	**0.67**	**0.55**	**0.54**	**0.57**	**0.57**
Backcasts (after Qt)										
Qt+1, mid-M1	**0.71**	**0.72**	**0.84**	**0.83**	**0.77**	**0.78**	**0.62**	**0.62**	**0.66**	**0.66**
Qt+1, end-M1	**0.70**	**0.71**	**0.83**	**0.83**	**0.76**	**0.77**	**0.61**	**0.61**	**0.65**	**0.65**

Notes: Table entries are RMSFE average across suite relative to the benchmark AR(1) model for the sequence of 20 forecasts considered for each quarter (see Table 1); bold entries indicate relative RMSFE less than one (cases in which the RMSFE is better for the suite than the AR(1) benchmark); the evaluation sample is 2008 Q3 to 2016 Q2.

Source: authors' calculations.

As for Romania, for the Euro Area we next take a closer look at forecast performance over two sub-samples, in the case of the Euro Area 2008 Q3 – 2010 Q2 and 2010 Q3 – 2016 Q2. As in the case of Romania, the relative (to the respective AR(1) benchmark processes) RMSFE criterion the non-linear suite of models tends to be lower during the crisis for almost all GDP and components and forecast horizons, indicating better forecasting performance for the recession (crisis period) than the recovery (the post-crisis period), as documented in Table 9.

Table 9. Euro Area – forecast accuracy (point forecasts, crisis and post-crisis)

	2008 Q3 – 2010 Q2					2010 Q3 – 2016 Q2				
GDP component	GDP	Consumption	Investment	Imports	Exports	GDP	Consumption	Investment	Imports	Exports
Forecasts (before Qt)										
Qt-2, mid-M1	**0.53**	1.01	**0.81**	**0.86**	**0.73**	0.99	**0.92**	0.97	0.96	0.96
Qt-2, end-M1	**0.51**	1.00	**0.80**	**0.83**	**0.71**	0.99	**0.92**	0.96	0.96	0.95
Qt-2, mid-M2	**0.52**	0.99	**0.79**	**0.84**	**0.71**	0.99	**0.92**	0.96	0.95	0.95
Qt-2, end-M2	**0.50**	0.98	**0.78**	**0.83**	**0.70**	0.96	**0.91**	0.94	0.95	0.99
Qt-2, mid-M3	**0.50**	0.98	**0.78**	**0.84**	**0.69**	0.97	**0.91**	0.94	0.94	0.98
Qt-2, end-M3	**0.49**	0.97	**0.76**	**0.82**	**0.68**	0.96	**0.90**	0.94	0.95	0.97
Qt-1, mid-M1	**0.61**	0.89	**0.75**	**0.81**	**0.73**	1.06	**0.87**	1.00	1.06	1.12
Qt-1, end-M1	**0.58**	**0.83**	**0.71**	**0.74**	**0.68**	1.07	0.86	1.01	1.07	1.11
Qt-1, mid-M2	**0.58**	**0.83**	**0.70**	**0.72**	**0.68**	1.04	0.86	0.99	1.05	1.10
Qt-1, end-M2	**0.56**	**0.83**	**0.68**	**0.70**	**0.66**	1.00	0.84	0.97	1.01	1.08
Qt-1, mid-M3	**0.55**	**0.83**	**0.67**	**0.68**	**0.65**	1.00	0.84	0.94	1.00	1.09
Qt-1, end-M3	**0.54**	**0.81**	**0.66**	**0.65**	**0.62**	0.99	0.84	0.93	1.00	1.10
Nowcasts (in Qt)										
Qt, mid-M1	**0.66**	**0.72**	**0.72**	**0.65**	**0.68**	1.03	0.87	0.90	1.07	1.15
Qt, end-M1	**0.64**	**0.69**	**0.70**	**0.62**	**0.65**	1.05	0.88	0.91	1.06	1.15
Qt, mid-M2	**0.61**	**0.66**	**0.66**	**0.57**	**0.61**	1.01	0.87	0.90	1.02	1.12
Qt, end-M2	**0.59**	**0.65**	**0.64**	**0.55**	**0.59**	0.99	0.86	0.89	1.00	1.11
Qt, mid-M3	**0.57**	**0.63**	**0.63**	**0.52**	**0.57**	0.98	0.85	0.90	0.99	1.12
Qt, end-M3	**0.57**	**0.62**	**0.62**	**0.51**	**0.55**	0.97	0.84	0.90	0.97	1.14
Backcasts (after Qt)										
Qt+1, mid-M1	**0.69**	**0.74**	**0.73**	**0.58**	**0.64**	0.86	0.91	0.87	0.81	0.85
Qt+1, end-M1	**0.68**	**0.73**	**0.72**	**0.58**	**0.63**	0.86	0.91	0.86	0.81	0.85

Notes: Table entries are RMSFE average (equal weights) across suite relative to the benchmark AR(1) model, bold entries indicate cases in which the relative (to an AR(1) process) RMSFE is better in one of the sub-sample as compared to the other one.

Source: authors' calculations.

Regarding the indicators most useful as predictors in the case of the Euro Area[3], the group of survey data (for the genuine forecasts) and, to a lesser extent, industrial production (for the nowcasts and backcasts), produce forecasts that clearly dominate forecasts produced from indicators belonging to other groups of variables in terms of the RMSFE criterion, for all GDP and expenditure components. This is a clear reflection of the greater importance of the more domestic developments (as opposed to the international context, as in the case of Romania) for the economic outlook of that entity.

3 The results are available upon request.

3.2.3. Overall predictive ability (density forecasts)

Also for the Euro Area, as for Romania, combined densities were computed (across indicators) for each model specification and then across the model specifications using, alternatively, equal-weights or recursive weights. The results (shown in Table 10) indicate that the suite of non-linear SIMs performs better than the corresponding AR(1) benchmarks for all components and at all forecast horizons.

Table 10. Euro Area – forecast accuracy (density forecasts)

GDP component	GDP		Consumption		Investment		Imports		Exports	
Weights	equal	recursive	equal	recursive	equal	recursive	equal	recursive	equal	recursive
Forecasts (before Qt)										
Forecast Qt-2, mid-M1	0.34	0.35	0.16	0.16	0.31	0.31	0.37	0.35	0.37	0.38
Forecast Qt-2, end-M1	0.34	0.35	0.16	0.16	0.31	0.31	0.37	0.35	0.37	0.38
Forecast Qt-2, mid-M2	0.34	0.35	0.16	0.16	0.31	0.31	0.37	0.35	0.37	0.38
Forecast Qt-2, end-M2	0.34	0.35	0.16	0.16	0.31	0.31	0.37	0.35	0.37	0.36
Forecast Qt-2, mid-M3	0.34	0.35	0.16	0.16	0.31	0.31	0.37	0.36	0.37	0.35
Forecast Qt-2, end-M3	0.34	0.35	0.16	0.16	0.31	0.30	0.37	0.35	0.37	0.34
Forecast Qt-1, mid-M1	0.33	0.32	0.18	0.18	0.32	0.32	0.38	0.37	0.38	0.38
Forecast Qt-1, end-M1	0.33	0.34	0.18	0.18	0.32	0.31	0.38	0.38	0.38	0.39
Forecast Qt-1, mid-M2	0.33	0.34	0.18	0.18	0.32	0.32	0.38	0.38	0.38	0.39
Forecast Qt-1, end-M2	0.33	0.34	0.18	0.18	0.32	0.31	0.38	0.38	0.38	0.39
Forecast Qt-1, mid-M3	0.33	0.34	0.18	0.18	0.32	0.32	0.38	0.38	0.38	0.39
Forecast Qt-1, end-M3	0.33	0.35	0.18	0.18	0.32	0.31	0.38	0.38	0.38	0.39
Nowcasts (in Qt)										
Nowcast Qt, mid-M1	0.27	0.23	0.17	0.17	0.27	0.26	0.34	0.34	0.34	0.33
Nowcast Qt, end-M1	0.27	0.23	0.17	0.17	0.27	0.27	0.34	0.34	0.34	0.33
Nowcast Qt, mid-M2	0.27	0.23	0.17	0.17	0.27	0.26	0.34	0.34	0.34	0.33
Nowcast Qt, end-M2	0.27	0.23	0.17	0.17	0.27	0.26	0.34	0.34	0.34	0.34
Nowcast Qt, mid-M3	0.27	0.23	0.17	0.17	0.27	0.26	0.34	0.34	0.34	0.34
Nowcast Qt, end-M3	0.27	0.24	0.17	0.17	0.27	0.26	0.34	0.35	0.34	0.34
Backcasts (after Qt)										
Backcast Qt+1, mid-M1	0.18	0.12	0.11	0.11	0.16	0.15	0.25	0.25	0.24	0.24
Backcast Qt+1, end-M1	0.18	0.12	0.11	0.11	0.16	0.15	0.25	0.25	0.23	0.24

Notes: The tables show the average logarithmic score for the suite for the sequence of 20 forecasts produced for each quarter.
Source: authors' calculations.

As regards the performance of the different model specifications, in the case of the Euro Area, the STAR specifications displays the highest average logarithmic score for all GDP and GDP components and at all forecast horizons, again independently of the weights chosen for the combination (see Tables B.3.1 to B.3.5 in Appendix B). The average logarithmic score increases generally across forecast horizons with more information becoming available, pointing to an improvement of density forecast accuracy with increasing proximity to the target date, and this for all components.

The normality of the transformed pits is generally not rejected across components and forecast horizons, perhaps with the exception of the 1-quarter-ahead forecasts for GDP. This is mainly due to the fact that, for this component, the models are not able to capture well in advance the large downturns registered in the case of the first recession episode in the sample. Independence of the transformed pits is rejected for GDP and all components at all horizons. The share of correctly calibrated densities in terms of independence tests across components and forecast horizons is much higher in the case of the Euro Area than in the case of Romania. Normality and independence (Berkovitz test) of the transformed pits is rejected at 5 percent significance level for GDP and all components and forecast horizons.

4. Conclusions

This paper assesses the predictive performance of a suite of non-linear SIMs for GDP and GDP expenditure components for Romania and the Euro Area, notably during the 'great' recession and the subsequent 'poor' recovery. The main finding of the paper is that predicting the great recession and the subsequent recovery with a suite of non-linear SIMs would have been possible in the case of Romania and the Euro Area. Both point and density forecasts would have indicated a possibility, if not likelihood, of growth going negative in late 2008/early 2009 and positive in late 2009, and of growth staying negative/positive for more than one quarter.

Also as a mere complement to more traditional linear models, and particularly for the period of the crises (2008 Q3 – 2010 Q2), the non-linear models therefore would have been useful by supporting the evidence for a turn in a cycle, thus giving forecasters an additional lead time for their predictions. In our judgement, this provides strong support for the use of this class of models, even if they may be difficult to set up and may take more computing time. Further, the paper suggests that in forecasting practice, those models (just like linear models) are best considered in the context of a suite, as at least from a point forecasting perspective the best performing model differs along the horizon and across variables (i.e. there is no best model).

Considering the results in a little more detail, the trough of the 'great' recession would have been signaled by forecasts turning negative a couple of month in advance than the official GDP release for both Romania and the Euro Area. The signal of a downturn would have been timelier in the case of the Euro Area. The signal of an upswing (a positive growth rate after a sequence of negative outcomes) would have been timelier in the case of Romania. The recession, defined here as 2 consecutive quarters of negative growth, would have been signaled earlier in the case of the Euro Area than for Romania.

Comparing the results for Romania and the Euro Area aggregate, it appears as if forecast accuracy of the non-linear SIMs is higher for the Euro Area than for Romania, both for point forecasts and density forecasts and equal weights combination strategy tends to provide similar forecast accuracy to that of the recursive time-varying scheme. Differences in the results between Romania and the Euro Area aggregate can be observed also regarding the most useful predictors, with forecasts based on international data (and to a lesser extent those related to surveys and industrial production) tend to be more accurate in the case of Romania, while for the Euro Area it is those based on survey and industrial production data.

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Appendix

A. ROMANIA

A.1. Information set (indicators available at monthly frequency)

Table A.1. Indicators (groups, series and transformations)

No.	Group	Series	Transformations	
			Logarithms	Differences
1	Industrial Production (IP)	Indices of construction works, seasonally adjusted	1	1
2	Industrial Production (IP)	Industrial production	1	1
3	Industrial Production (IP)	Industrial production of durable goods	1	1
4	Industrial Production (IP)	Industrial production in energy	1	1
5	Industrial Production (IP)	Industrial production of intermediate goods	1	1
6	Industrial Production (IP)	Industrial production of nondurable goods	1	1
7	Industrial Production (IP)	Retail sales turnover index (except for motor vehicles and motorcycles)	1	1
8	International (Intl)	Economic sentiment indicator, euro area	0	1
9	International (Intl)	EA19 Industrial production index	1	1
10	International (Intl)	EuroStoxx 325 index	1	1
11	Money	Stock market index	1	1
12	Money	RON/EUR exchange rate, real	1	1
13	Money	RON/USD exchange rate, real	1	1
14	Surveys	Construction confidence indicator	0	1
15	Surveys	Consumer Confidence Indicator	0	1
16	Surveys	Economic sentiment indicator	0	1
17	Surveys	Industrial confidence indicator	0	1
18	Surveys	Retail confidence indicator	0	1

Source: authors' calculations.

A.2. Timeliness of the signal

Table A.2.1. Consumption

	Predicted probability of negative growth in 2008 Q4				Predicted probability of positive growth in 2009 Q2		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Apr. (mid)	0.00	0.04	0.05	2008 Oct. (mid)	**1.00**	**0.96**	**0.95**
2008 Apr. (end)	0.00	0.05	0.05	2008 Oct. (end)	**1.00**	**0.96**	**0.95**
2008 May (mid)	0.00	0.05	0.05	2008 Nov. (mid)	**1.00**	**0.96**	**0.95**
2008 May (end)	0.00	0.05	0.05	2008 Nov. (end)	**1.00**	**0.96**	**0.94**
2008 Jun. (mid)	0.00	0.05	0.05	2008 Dec. (mid)	**1.00**	**0.96**	**0.95**
2008 Jun. (end)	0.00	0.05	0.05	2008 Dec. (end)	**1.00**	**0.95**	**0.94**
2008 Jul. (mid)	0.00	0.06	0.07	2009 Jan. (mid)	**1.00**	**0.90**	**0.93**
2008 Jul. (end)	0.00	0.07	0.07	2009 Jan. (end)	**1.00**	**0.88**	**0.92**
2008 Aug. (mid)	0.00	0.07	0.08	2009 Feb. (mid)	**1.00**	**0.84**	**0.90**
2008 Aug. (end)	0.00	0.07	0.08	2009 Feb. (end)	**1.00**	**0.80**	**0.89**
2008 Sep. (mid)	0.00	0.09	0.09	2009 Mar. (mid)	**1.00**	**0.78**	**0.88**
2008 Sep. (end)	0.00	0.09	0.09	2009 Mar. (end)	**1.00**	**0.77**	**0.88**
Nowcasts (in Qt)				Nowcasts (in Qt)			
2008 Oct. (mid)	0.00	0.09	0.10	2009 Apr. (mid)	0.13	0.33	0.26
2008 Oct. (end)	0.00	0.09	0.10	2009 Apr. (end)	0.13	0.35	0.29
2008 Nov. (mid)	0.00	0.09	0.10	2009 May (mid)	0.13	0.34	0.29
2008 Nov. (end)	0.00	0.13	0.11	2009 May (end)	0.13	0.36	0.30
2008 Dec. (mid)	0.00	0.12	0.11	2009 Jun. (mid)	0.25	0.36	0.30
2008 Dec. (end)	0.00	0.14	0.11	2009 Jun. (end)	0.38	0.36	0.31
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Jan. (mid)	0.00	0.15	0.09	2009 Jul. (mid)	**0.50**	**0.56**	0.37
2009 Jan. (end)	0.00	0.15	0.09	2009 Jul. (end)	**0.50**	**0.56**	0.37

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

Table A.2.2. Investment

	Predicted probability of negative growth in 2009 Q1				Predicted probability of positive growth in 2009 Q3		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Jul. (mid)	0.00	0.20	0.24	2009 Jan. (mid)	**1.00**	**0.76**	**0.76**
2008 Jul. (end)	0.00	0.21	0.24	2009 Jan. (end)	**1.00**	**0.77**	**0.76**
2008 Aug. (mid)	0.00	0.21	0.24	2009 Feb. (mid)	**1.00**	**0.68**	**0.73**
2008 Aug. (end)	0.00	0.21	0.24	2009 Feb. (end)	**1.00**	**0.68**	**0.73**
2008 Sep. (mid)	0.00	0.20	0.24	2009 Mar. (mid)	**1.00**	**0.62**	**0.70**
2008 Sep. (end)	0.00	0.22	0.25	2009 Mar. (end)	**1.00**	**0.62**	**0.70**
2008 Oct. (mid)	0.00	0.23	0.25	2009 Apr. (mid)	**1.00**	**0.71**	**0.70**
2008 Oct. (end)	0.00	0.31	0.28	2009 Apr. (end)	**1.00**	**0.73**	**0.73**
2008 Nov. (mid)	0.00	0.32	0.29	2009 May (mid)	**1.00**	**0.74**	**0.74**
2008 Nov. (end)	0.00	0.36	0.30	2009 May (end)	**1.00**	**0.74**	**0.74**
2008 Dec. (mid)	0.00	0.41	0.34	2009 Jun. (mid)	**1.00**	**0.75**	**0.75**
2008 Dec. (end)	0.00	0.43	0.35	2009 Jun. (end)	**1.00**	**0.75**	**0.75**
Nowcasts (in Qt)				Nowcasts (in Qt)			
2009 Jan. (mid)	0.00	0.42	0.40	2009 Jul. (mid)	**0.75**	**0.61**	**0.58**
2009 Jan. (end)	0.00	0.43	0.41	2009 Jul. (end)	**0.75**	**0.60**	**0.58**
2009 Feb. (mid)	0.00	0.46	0.44	2009 Aug. (mid)	**0.75**	**0.60**	**0.58**
2009 Feb. (end)	0.25	0.49	0.46	2009 Aug. (end)	**0.75**	**0.58**	**0.57**
2009 Mar. (mid)	0.38	**0.50**	0.47	2009 Sep. (mid)	**0.75**	**0.56**	**0.57**
2009 Mar. (end)	0.38	**0.51**	0.47	2009 Sep. (end)	**0.75**	**0.56**	**0.57**
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Apr. (mid)	0.13	**0.57**	0.46	2009 Oct. (mid)	0.00	0.31	0.27
2009 Apr. (end)	0.13	**0.57**	0.46	2009 Oct. (end)	0.00	0.31	0.27

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

Table A.2.3. Imports

	Predicted probability of negative growth in 2008 Q4				Predicted probability of positive growth in 2009 Q3		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Apr. (mid)	0.00	0.13	0.13	2009 Jan. (mid)	**1.00**	**0.72**	**0.77**
2008 Apr. (end)	0.00	0.14	0.13	2009 Jan. (end)	**1.00**	**0.78**	**0.78**
2008 May (mid)	0.00	0.14	0.13	2009 Feb. (mid)	**1.00**	**0.70**	**0.74**
2008 May (end)	0.00	0.14	0.13	2009 Feb. (end)	**1.00**	**0.69**	**0.73**
2008 Jun. (mid)	0.00	0.15	0.13	2009 Mar. (mid)	**1.00**	**0.61**	**0.69**
2008 Jun. (end)	0.00	0.17	0.14	2009 Mar. (end)	**1.00**	**0.60**	**0.69**
2008 Jul. (mid)	0.00	0.15	0.15	2009 Apr. (mid)	**0.75**	**0.38**	**0.57**
2008 Jul. (end)	0.00	0.16	0.16	2009 Apr. (end)	**0.88**	**0.49**	**0.64**
2008 Aug. (mid)	0.00	0.16	0.16	2009 May (mid)	**0.88**	**0.49**	**0.66**
2008 Aug. (end)	0.00	0.17	0.15	2009 May (end)	**1.00**	**0.51**	**0.69**
2008 Sep. (mid)	0.00	0.18	0.16	2009 Jun. (mid)	**1.00**	**0.51**	**0.69**
2008 Sep. (end)	0.00	0.20	0.16	2009 Jun. (end)	**1.00**	**0.53**	**0.71**
Nowcasts (in Qt)				Nowcasts (in Qt)			
2008 Oct. (mid)	0.00	0.21	0.24	2009 Jul. (mid)	**0.63**	**0.67**	**0.57**
2008 Oct. (end)	0.00	0.25	0.22	2009 Jul. (end)	**0.63**	**0.67**	**0.57**
2008 Nov. (mid)	0.00	0.26	0.22	2009 Aug. (mid)	**0.63**	**0.65**	**0.57**
2008 Nov. (end)	0.00	0.28	0.23	2009 Aug. (end)	**0.63**	**0.64**	**0.56**
2008 Dec. (mid)	0.00	0.30	0.25	2009 Sep. (mid)	**0.63**	**0.66**	**0.57**
2008 Dec. (end)	0.00	0.30	0.25	2009 Sep. (end)	**0.63**	**0.66**	**0.58**
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Jan. (mid)	0.00	0.43	0.34	2009 Oct. (mid)	**0.75**	**0.63**	**0.67**
2009 Jan. (end)	0.00	0.42	0.34	2009 Oct. (end)	**0.75**	**0.63**	**0.67**

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

Table A.2.4. Exports

Criterion	Predicted probability of negative growth in 2008 Q4: Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Predicted probability of positive growth in 2009 Q3: Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Apr. (mid)	0.00	0.24	0.25	2009 Jan. (mid)	**1.00**	**0.67**	**0.65**
2008 Apr. (end)	0.00	0.24	0.25	2009 Jan. (end)	**1.00**	**0.68**	**0.66**
2008 May (mid)	0.00	0.24	0.25	2009 Feb. (mid)	**1.00**	**0.67**	**0.63**
2008 May (end)	0.00	0.30	0.25	2009 Feb. (end)	**1.00**	**0.63**	**0.62**
2008 Jun. (mid)	0.00	0.31	0.25	2009 Mar. (mid)	**1.00**	**0.57**	**0.60**
2008 Jun. (end)	0.00	0.35	0.26	2009 Mar. (end)	**1.00**	**0.57**	**0.60**
2008 Jul. (mid)	0.00	0.17	0.26	2009 Apr. (mid)	**0.75**	**0.58**	**0.56**
2008 Jul. (end)	0.00	0.18	0.27	2009 Apr. (end)	**0.88**	**0.59**	**0.59**
2008 Aug. (mid)	0.00	0.18	0.27	2009 May (mid)	**0.88**	**0.62**	**0.61**
2008 Aug. (end)	0.00	0.19	0.27	2009 May (end)	**1.00**	**0.63**	**0.64**
2008 Sep. (mid)	0.00	0.20	0.27	2009 Jun. (mid)	**1.00**	**0.65**	**0.64**
2008 Sep. (end)	0.00	0.20	0.27	2009 Jun. (end)	**1.00**	**0.65**	**0.65**
Nowcasts (in Qt)				Nowcasts (in Qt)			
2008 Oct. (mid)	0.00	0.25	0.34	2009 Jul. (mid)	**1.00**	**0.71**	**0.70**
2008 Oct. (end)	0.00	0.25	0.34	2009 Jul. (end)	**1.00**	**0.70**	**0.69**
2008 Nov. (mid)	0.00	0.25	0.34	2009 Aug. (mid)	**1.00**	**0.69**	**0.69**
2008 Nov. (end)	0.00	0.26	0.35	2009 Aug. (end)	**1.00**	**0.69**	**0.70**
2008 Dec. (mid)	0.00	0.27	0.35	2009 Sep. (mid)	**1.00**	**0.70**	**0.71**
2008 Dec. (end)	0.00	0.27	0.36	2009 Sep. (end)	**1.00**	**0.70**	**0.71**
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Jan. (mid)	**0.50**	0.36	0.44	2009 Oct. (mid)	**1.00**	**0.67**	**0.66**
2009 Jan. (end)	**0.50**	0.37	0.44	2009 Oct. (end)	**1.00**	**0.67**	**0.66**

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

A.3. Best models and diagnostics

Table A.3.1. GDP

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	ESTAR	Ct	0.67	0	0
Qt-2, end-M1	ESTAR	Ct	0.67	0	0
Qt-2, mid-M2	ESTAR	Ct	0.67	0	0
Qt-2, end-M2	ESTAR	Ct	0.67	0	0
Qt-2, mid-M3	ESTAR	Ct	0.67	0	0
Qt-2, end-M3	ESTAR	Ct	0.67	0	0
Qt-1, mid-M1	ESTAR	Ct	0.33	0	0
Qt-1, end-M1	ESTAR	Ct	0.33	0	0
Qt-1, mid-M2	ESTAR	Ct	0.33	0	0
Qt-1, end-M2	ESTAR	Ct	0.33	0	0
Qt-1, mid-M3	ESTAR	Ct	0.33	0	0
Qt-1, end-M3	ESTAR	Ct	0.33	0	0
Nowcasts (in Qt)					
Qt, mid-M1	ESTAR	Ct	0.67	-	-
Qt, end-M1	ESTAR	Ct	0.67	-	-
Qt, mid-M2	ESTAR	Ct	0.67	-	-
Qt, end-M2	ESTAR	Ct	0.67	-	-
Qt, mid-M3	ESTAR	Ct	0.67	-	-
Qt, end-M3	ESTAR	Ct	0.67	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	LSTAR	ESTAR	1.00	-	-
Qt+1, end-M1	LSTAR	ESTAR	1.00	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

Table A.3.2. Consumption

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	IndVar	LSTAR	0.00	0	1
Qt-2, end-M1	IndVar	LSTAR	0.00	0	1
Qt-2, mid-M2	IndVar	LSTAR	0.00	0	1
Qt-2, end-M2	IndVar	LSTAR	0.00	0	1
Qt-2, mid-M3	IndVar	LSTAR	0.00	0	1
Qt-2, end-M3	IndVar	LSTAR	0.00	0	1
Qt-1, mid-M1	AllVar	ESTAR	0.33	0	1
Qt-1, end-M1	AllVar	ESTAR	0.33	0	1
Qt-1, mid-M2	AllVar	ESTAR	0.33	0	1
Qt-1, end-M2	AllVar	ESTAR	0.33	0	1
Qt-1, mid-M3	AllVar	ESTAR	0.33	0	1
Qt-1, end-M3	AllVar	ESTAR	0.33	0	1
Nowcasts (in Qt)					
Qt, mid-M1	LSTAR	ESTAR	0.33	-	-
Qt, end-M1	LSTAR	ESTAR	0.33	-	-
Qt, mid-M2	LSTAR	ESTAR	0.33	-	-
Qt, end-M2	LSTAR	ESTAR	0.33	-	-
Qt, mid-M3	LSTAR	ESTAR	0.00	-	-
Qt, end-M3	LSTAR	ESTAR	0.33	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	LSTAR	ESTAR	0.67	-	-
Qt+1, end-M1	LSTAR	ESTAR	0.67	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

Table A.3.3. Investment

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	ESTAR	Ct	0.33	0	1
Qt-2, end-M1	ESTAR	Ct	0.33	0	1
Qt-2, mid-M2	ESTAR	Ct	0.33	0	1
Qt-2, end-M2	ESTAR	Ct	0.33	0	1
Qt-2, mid-M3	ESTAR	Ct	0.33	0	1
Qt-2, end-M3	ESTAR	Ct	0.33	0	1
Qt-1, mid-M1	Var	LSTAR	0.00	0	1
Qt-1, end-M1	Var	LSTAR	0.00	0	1
Qt-1, mid-M2	Ind	LSTAR	0.00	0	1
Qt-1, end-M2	Ind	LSTAR	0.00	0	1
Qt-1, mid-M3	Ind	LSTAR	0.00	0	1
Qt-1, end-M3	Ind	LSTAR	0.00	0	1
Nowcasts (in Qt)					
Qt, mid-M1	AllVar	LSTAR	0.00	-	-
Qt, end-M1	AllVar	LSTAR	0.00	-	-
Qt, mid-M2	AllVar	LSTAR	0.00	-	-
Qt, end-M2	AllVar	LSTAR	0.00	-	-
Qt, mid-M3	AllVar	LSTAR	0.00	-	-
Qt, end-M3	AllVar	LSTAR	0.00	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	AllVar	LSTAR	0.67	-	-
Qt+1, end-M1	AllVar	LSTAR	0.67	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

Table A.3.4. Imports

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	LSTAR	LSTAR	0.33	0	1
Qt-2, end-M1	LSTAR	LSTAR	0.33	0	1
Qt-2, mid-M2	LSTAR	LSTAR	0.33	0	1
Qt-2, end-M2	LSTAR	LSTAR	0.33	0	1
Qt-2, mid-M3	LSTAR	LSTAR	0.33	0	1
Qt-2, end-M3	LSTAR	LSTAR	0.33	0	1
Qt-1, mid-M1	AllVar	LSTAR	0.33	0	1
Qt-1, end-M1	AllVar	LSTAR	0.00	0	1
Qt-1, mid-M2	AllVar	LSTAR	0.00	0	1
Qt-1, end-M2	AllVar	LSTAR	0.00	0	1
Qt-1, mid-M3	AllVar	LSTAR	0.00	1	1
Qt-1, end-M3	AllVar	LSTAR	0.33	1	1
Nowcasts (in Qt)					
Qt, mid-M1	AllVar	LSTAR	0.67	-	-
Qt, end-M1	AllVar	LSTAR	0.33	-	-
Qt, mid-M2	AllVar	LSTAR	0.33	-	-
Qt, end-M2	AllVar	LSTAR	0.33	-	-
Qt, mid-M3	AllVar	LSTAR	0.00	-	-
Qt, end-M3	AllVar	LSTAR	0.00	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	Ind	LSTAR	0.67	-	-
Qt+1, end-M1	Ind	LSTAR	0.67	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

Table A.3.5. Exports

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	LSTAR	ESTAR	0.67	1	1
Qt-2, end-M1	LSTAR	ESTAR	0.67	0	1
Qt-2, mid-M2	AllVar	ESTAR	0.67	0	1
Qt-2, end-M2	AllVar	LSTAR	0.67	1	1
Qt-2, mid-M3	AllVar	LSTAR	0.67	1	1
Qt-2, end-M3	LSTAR	LSTAR	0.67	1	1
Qt-1, mid-M1	IndVar	ESTAR	0.67	1	1
Qt-1, end-M1	IndVar	ESTAR	0.67	1	1
Qt-1, mid-M2	IndVar	ESTAR	0.67	1	1
Qt-1, end-M2	IndVar	ESTAR	0.67	1	1
Qt-1, mid-M3	Var	ESTAR	0.67	1	1
Qt-1, end-M3	Var	ESTAR	0.67	1	1
Nowcasts (in Qt)					
Qt, mid-M1	IndVar	ESTAR	0.67	-	-
Qt, end-M1	IndVar	ESTAR	0.67	-	-
Qt, mid-M2	CtVar	ESTAR	0.67	-	-
Qt, end-M2	CtVar	ESTAR	0.67	-	-
Qt, mid-M3	CtVar	ESTAR	0.67	-	-
Qt, end-M3	CtVar	ESTAR	0.67	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	LSTAR	ESTAR	0.67	-	-
Qt+1, end-M1	LSTAR	ESTAR	0.67	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

B. EURO AREA

B.1. Information set (indicators available at monthly frequency)

Table B.1. Indicators (groups, series and transformations)

No.	Group	Series	Transformations	
			Logarithms	Differences
1	Industrial Production (IP)	Industrial production	1	1
2	Industrial Production (IP)	Industrial production in construction, seasonally adjusted	1	1
3	Industrial Production (IP)	Industrial production in energy	1	1
4	Industrial Production (IP)	Industrial production of capital goods	1	1
5	Industrial Production (IP)	Industrial production of durable goods	1	1
6	Industrial Production (IP)	Industrial production of intermediate goods	1	1
7	Industrial Production (IP)	Industrial production of nondurable goods	1	1
8	International (Intl)	S&P500	1	1
9	International (Intl)	Sentiment indicator, US	0	1
10	International (Intl)	US Industrial production index	1	1
11	Money	EuroStoxx 325	1	1
12	Money	EUR/GBP exchange rate, real	1	1
13	Money	EUR/USD exchange rate, real	1	1
14	Surveys	Construction confidence indicator	0	1
15	Surveys	Consumer confidence Indicator	0	1
16	Surveys	Economic sentiment indicator	0	1
17	Surveys	Industrial confidence indicator	0	1
18	Surveys	Retail confidence indicator	0	1

Source: authors' calculations.

B. 2. Timeliness of the signal

Table B.2.1. Consumption

	Predicted probability of negative growth in 2009 Q1				Predicted probability of positive growth in 2009 Q2		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Jul. (mid)	0.00	0.04	0.05	2008 Oct. (mid)	**1.00**	**0.93**	**0.91**
2008 Jul. (end)	0.00	0.04	0.05	2008 Oct. (end)	**1.00**	**0.83**	**0.89**
2008 Aug. (mid)	0.00	0.04	0.05	2008 Nov. (mid)	**1.00**	**0.83**	**0.89**
2008 Aug. (end)	0.00	0.04	0.05	2008 Nov. (end)	**1.00**	**0.89**	**0.89**
2008 Sep. (mid)	0.00	0.04	0.05	2008 Dec. (mid)	**1.00**	**0.89**	**0.90**
2008 Sep. (end)	0.00	0.06	0.05	2008 Dec. (end)	**1.00**	**0.82**	**0.84**
2008 Oct. (mid)	0.00	0.11	0.11	2009 Jan. (mid)	**0.75**	**0.52**	**0.63**
2008 Oct. (end)	0.00	0.18	0.21	2009 Jan. (end)	**0.75**	**0.53**	**0.66**
2008 Nov. (mid)	0.00	0.17	0.21	2009 Feb. (mid)	**0.63**	**0.51**	0.49
2008 Nov. (end)	0.00	0.21	0.22	2009 Feb. (end)	0.13	0.45	0.32
2008 Dec. (mid)	0.00	0.21	0.23	2009 Mar. (mid)	0.13	0.45	0.30
2008 Dec. (end)	0.00	0.24	0.27	2009 Mar. (end)	0.13	0.47	0.29
Nowcasts (in Qt)				Nowcasts (in Qt)			
2009 Jan. (mid)	**0.75**	0.48	**0.67**	2009 Apr. (mid)	0.00	0.45	0.27
2009 Jan. (end)	**0.88**	0.49	**0.71**	2009 Apr. (end)	0.13	0.47	0.34
2009 Feb. (mid)	**1.00**	**0.52**	**0.81**	2009 May (mid)	0.13	0.46	0.34
2009 Feb. (end)	**1.00**	**0.57**	**0.88**	2009 May (end)	0.25	0.49	0.39
2009 Mar. (mid)	**1.00**	**0.57**	**0.89**	2009 Jun. (mid)	**0.50**	**0.51**	0.41
2009 Mar. (end)	**1.00**	**0.56**	**0.89**	2009 Jun. (end)	**0.50**	**0.51**	0.43
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Apr. (mid)	**1.00**	**0.68**	**0.89**	2009 Jul. (mid)	0.00	0.36	0.31
2009 Apr. (end)	**1.00**	**0.68**	**0.88**	2009 Jul. (end)	0.13	0.36	0.32

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

Table B.2.2. Investment

	Predicted probability of negative growth in 2009 Q1				Predicted probability of positive growth in 2010 Q2		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Jul. (mid)	0.00	0.15	0.18	2009 Oct. (mid)	**0.75**	**0.59**	**0.56**
2008 Jul. (end)	0.00	0.16	0.19	2009 Oct. (end)	**0.75**	**0.62**	**0.60**
2008 Aug. (mid)	0.00	0.16	0.19	2009 Nov. (mid)	**0.75**	**0.64**	**0.62**
2008 Aug. (end)	0.00	0.15	0.19	2009 Nov. (end)	**0.75**	**0.65**	**0.66**
2008 Sep. (mid)	0.00	0.15	0.20	2009 Dec. (mid)	**0.75**	**0.65**	**0.64**
2008 Sep. (end)	0.00	0.16	0.21	2009 Dec. (end)	**0.88**	**0.68**	**0.67**
2008 Oct. (mid)	0.13	**0.51**	0.34	2010 Jan. (mid)	**1.00**	**0.60**	**0.81**
2008 Oct. (end)	**0.75**	**0.59**	**0.55**	2010 Jan. (end)	**1.00**	**0.62**	**0.83**
2008 Nov. (mid)	**0.75**	**0.59**	**0.55**	2010 Feb. (mid)	**1.00**	**0.62**	**0.83**
2008 Nov. (end)	**0.88**	**0.56**	**0.60**	2010 Feb. (end)	**1.00**	**0.57**	**0.80**
2008 Dec. (mid)	**1.00**	**0.58**	**0.63**	2010 Mar. (mid)	**1.00**	**0.60**	**0.83**
2008 Dec. (end)	**1.00**	**0.59**	**0.71**	2010 Mar. (end)	**1.00**	**0.65**	**0.86**
Nowcasts (in Qt)				Nowcasts (in Qt)			
2009 Jan. (mid)	**0.88**	**0.74**	**0.74**	2010 Apr. (mid)	**0.88**	**0.67**	**0.71**
2009 Jan. (end)	**0.88**	**0.78**	**0.76**	2010 Apr. (end)	**1.00**	**0.69**	**0.73**
2009 Feb. (mid)	**0.88**	**0.75**	**0.88**	2010 May (mid)	**1.00**	**0.72**	**0.77**
2009 Feb. (end)	**0.88**	**0.76**	**0.90**	2010 May (end)	**1.00**	**0.73**	**0.78**
2009 Mar. (mid)	**0.88**	**0.77**	**0.93**	2010 Jun. (mid)	**1.00**	**0.73**	**0.75**
2009 Mar. (end)	**0.88**	**0.78**	**0.93**	2010 Jun. (end)	**1.00**	**0.72**	**0.75**
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Apr. (mid)	**1.00**	**0.99**	**1.00**	2010 Jul. (mid)	0.25	0.40	0.43
2009 Apr. (end)	**1.00**	**0.99**	**1.00**	2010 Jul. (end)	0.25	0.45	0.44

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

Table B.2.3. Imports

	Predicted probability of negative growth in 2009 Q1				Predicted probability of positive growth in 2009 Q3		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Jul. (mid)	0.00	0.15	0.26	2009 Jan. (mid)	**0.88**	**0.61**	**0.59**
2008 Jul. (end)	0.00	0.17	0.27	2009 Jan. (end)	**1.00**	**0.66**	**0.62**
2008 Aug. (mid)	0.00	0.17	0.27	2009 Feb. (mid)	0.00	0.44	0.26
2008 Aug. (end)	0.00	0.16	0.27	2009 Feb. (end)	0.00	0.39	0.15
2008 Sep. (mid)	0.00	0.16	0.27	2009 Mar. (mid)	0.00	0.38	0.11
2008 Sep. (end)	0.00	0.20	0.29	2009 Mar. (end)	0.00	0.36	0.09
2008 Oct. (mid)	0.00	0.29	0.21	2009 Apr. (mid)	0.00	0.23	0.17
2008 Oct. (end)	0.25	**0.53**	0.45	2009 Apr. (end)	0.00	0.28	0.32
2008 Nov. (mid)	0.25	**0.55**	0.48	2009 May (mid)	0.13	0.27	0.38
2008 Nov. (end)	**0.50**	**0.57**	**0.54**	2009 May (end)	**0.88**	0.36	**0.51**
2008 Dec. (mid)	**0.88**	**0.61**	**0.58**	2009 Jun. (mid)	**0.88**	0.38	**0.55**
2008 Dec. (end)	**1.00**	**0.67**	**0.71**	2009 Jun. (end)	**0.88**	0.43	**0.62**
Nowcasts (in Qt)				Nowcasts (in Qt)			
2009 Jan. (mid)	**1.00**	**0.75**	**0.88**	2009 Jul. (mid)	0.13	0.19	0.23
2009 Jan. (end)	**1.00**	**0.78**	**0.89**	2009 Jul. (end)	0.13	0.21	0.26
2009 Feb. (mid)	**1.00**	**0.75**	**0.98**	2009 Aug. (mid)	0.13	0.20	0.28
2009 Feb. (end)	**1.00**	**0.76**	**0.99**	2009 Aug. (end)	0.38	0.23	0.32
2009 Mar. (mid)	**1.00**	**0.78**	**1.00**	2009 Sep. (mid)	0.38	0.24	0.35
2009 Mar. (end)	**1.00**	**0.78**	**1.00**	2009 Sep. (end)	0.38	0.25	0.35
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Apr. (mid)	**1.00**	**0.97**	**1.00**	2009 Oct. (mid)	**1.00**	**0.75**	**0.65**
2009 Apr. (end)	**1.00**	**0.97**	**1.00**	2009 Oct. (end)	**1.00**	**0.76**	**0.65**

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

Table B.2.4. Exports

	Predicted probability of negative growth in 2009 Q1				Predicted probability of positive growth in 2009 Q3		
Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)	Criterion	Point forecasts (share of models predicting sign)	Density forecasts (probability from best model)	Density forecasts (probability from EW combination)
Forecasts (before Qt)				Forecasts (before Qt)			
2008 Jul. (mid)	0.00	0.19	0.15	2009 Jan. (mid)	**1.00**	**0.51**	**0.62**
2008 Jul. (end)	0.00	0.21	0.17	2009 Jan. (end)	**1.00**	**0.55**	**0.64**
2008 Aug. (mid)	0.00	0.21	0.17	2009 Feb. (mid)	0.13	0.40	0.32
2008 Aug. (end)	0.00	0.21	0.16	2009 Feb. (end)	0.13	0.35	0.27
2008 Sep. (mid)	0.00	0.21	0.16	2009 Mar. (mid)	0.13	0.32	0.24
2008 Sep. (end)	0.00	0.25	0.18	2009 Mar. (end)	0.13	0.31	0.22
2008 Oct. (mid)	0.00	0.23	0.16	2009 Apr. (mid)	0.00	0.19	0.06
2008 Oct. (end)	0.13	**0.52**	0.36	2009 Apr. (end)	0.00	0.26	0.13
2008 Nov. (mid)	0.13	**0.53**	0.38	2009 May (mid)	0.00	0.26	0.18
2008 Nov. (end)	0.13	**0.57**	0.43	2009 May (end)	0.13	0.33	0.26
2008 Dec. (mid)	0.38	**0.60**	0.47	2009 Jun. (mid)	0.13	0.35	0.30
2008 Dec. (end)	**0.88**	**0.70**	**0.61**	2009 Jun. (end)	0.25	0.38	0.36
Nowcasts (in Qt)				Nowcasts (in Qt)			
2009 Jan. (mid)	**1.00**	**0.84**	**0.84**	2009 Jul. (mid)	0.00	0.22	0.04
2009 Jan. (end)	**1.00**	**0.85**	**0.84**	2009 Jul. (end)	0.00	0.25	0.06
2009 Feb. (mid)	**1.00**	**0.80**	**0.96**	2009 Aug. (mid)	0.00	0.26	0.07
2009 Feb. (end)	**1.00**	**0.80**	**0.98**	2009 Aug. (end)	0.00	0.29	0.09
2009 Mar. (mid)	**1.00**	**0.81**	**0.99**	2009 Sep. (mid)	0.00	0.29	0.10
2009 Mar. (end)	**1.00**	**0.81**	**0.99**	2009 Sep. (end)	0.00	0.30	0.11
Backcasts (after Qt)				Backcasts (after Qt)			
2009 Apr. (mid)	**1.00**	**0.96**	**1.00**	2009 Oct. (mid)	**1.00**	**0.89**	**0.90**
2009 Apr. (end)	**1.00**	**0.96**	**1.00**	2009 Oct. (end)	**1.00**	**0.88**	**0.90**

Notes: Table entries are measures of the predicted probability of a negative outcome at the trough of the recession (left panel) and a positive outcome at the onset of the recovery (right panel), computed for the sequence of 20 forecasts produced for each quarter; figures in bold show the cases when the probability of a negative/positive outcome is greater than 0.5.

Source: authors' calculations.

B.3. Best models and diagnostics

Table B.3.1. GDP

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	Ind	Var	0.33	0	0
Qt-2, end-M1	Ind	Var	0.33	0	0
Qt-2, mid-M2	Ind	Var	0.33	0	0
Qt-2, end-M2	Ind	Var	0.33	0	0
Qt-2, mid-M3	Ind	Var	0.33	0	0
Qt-2, end-M3	Ind	Var	0.33	0	0
Qt-1, mid-M1	Ind	Var	0.00	0	0
Qt-1, end-M1	Ind	Var	0.00	0	0
Qt-1, mid-M2	Ind	Var	0.00	0	0
Qt-1, end-M2	Ind	Var	0.00	0	0
Qt-1, mid-M3	Ind	Var	0.00	0	0
Qt-1, end-M3	Ind	Var	0.00	0	0
Nowcasts (in Qt)					
Qt, mid-M1	IndVar	ESTAR	0.67	-	-
Qt, end-M1	IndVar	ESTAR	0.67	-	-
Qt, mid-M2	IndVar	ESTAR	1.00	-	-
Qt, end-M2	IndVar	ESTAR	1.00	-	-
Qt, mid-M3	IndVar	ESTAR	1.00	-	-
Qt, end-M3	IndVar	ESTAR	1.00	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	Ind	ESTAR	1.00	-	-
Qt+1, end-M1	Ind	ESTAR	1.00	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

Table B.3.2. Consumption

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	Ct	Ct	0.67	0	0
Qt-2, end-M1	Ct	Ct	0.67	0	0
Qt-2, mid-M2	Ct	Ct	0.67	0	0
Qt-2, end-M2	Ct	Ct	0.67	0	0
Qt-2, mid-M3	Ct	Ct	0.67	0	0
Qt-2, end-M3	Ct	Ct	0.67	0	0
Qt-1, mid-M1	Ct	LSTAR	0.67	0	0
Qt-1, end-M1	Ct	LSTAR	0.67	0	0
Qt-1, mid-M2	Ct	LSTAR	0.67	0	0
Qt-1, end-M2	Ind	LSTAR	0.67	0	0
Qt-1, mid-M3	Ind	LSTAR	0.67	0	0
Qt-1, end-M3	Ind	LSTAR	0.67	0	0
Nowcasts (in Qt)					
Qt, mid-M1	Ind	LSTAR	0.67	-	-
Qt, end-M1	Ind	LSTAR	1.00	-	-
Qt, mid-M2	Ind	LSTAR	1.00	-	-
Qt, end-M2	IndVar	LSTAR	1.00	-	-
Qt, mid-M3	IndVar	LSTAR	1.00	-	-
Qt, end-M3	IndVar	LSTAR	1.00	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	IndVar	LSTAR	1.00	-	-
Qt+1, end-M1	IndVar	LSTAR	1.00	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

Table B.3.3. Investment

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	Var	Ind	0.33	0	0
Qt-2, end-M1	Var	Ind	0.33	0	0
Qt-2, mid-M2	Var	Ind	0.33	0	0
Qt-2, end-M2	Var	Ind	0.33	0	0
Qt-2, mid-M3	Var	Ind	0.33	0	0
Qt-2, end-M3	Var	Ind	0.33	0	0
Qt-1, mid-M1	IndVar	LSTAR	0.33	0	0
Qt-1, end-M1	CtVar	LSTAR	0.33	0	0
Qt-1, mid-M2	CtVar	LSTAR	0.33	0	0
Qt-1, end-M2	CtVar	LSTAR	0.33	0	0
Qt-1, mid-M3	CtVar	LSTAR	0.33	0	0
Qt-1, end-M3	CtVar	LSTAR	0.33	0	0
Nowcasts (in Qt)					
Qt, mid-M1	Ct	ESTAR	0.67	-	-
Qt, end-M1	Ct	ESTAR	1.00	-	-
Qt, mid-M2	Ct	ESTAR	1.00	-	-
Qt, end-M2	Ct	ESTAR	1.00	-	-
Qt, mid-M3	Ct	ESTAR	1.00	-	-
Qt, end-M3	Ct	ESTAR	1.00	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	Var	ESTAR	1.00	-	-
Qt+1, end-M1	Var	ESTAR	1.00	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

Table B.3.4. Imports

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	Var	Ct	0.33	0	0
Qt-2, end-M1	Var	Ct	0.33	0	0
Qt-2, mid-M2	Var	Ct	0.33	0	0
Qt-2, end-M2	Var	Ct	0.33	0	0
Qt-2, mid-M3	Var	Ct	0.33	0	0
Qt-2, end-M3	Var	Ct	0.33	0	0
Qt-1, mid-M1	IndVar	LSTAR	0.33	0	0
Qt-1, end-M1	Var	LSTAR	0.67	0	0
Qt-1, mid-M2	ESTAR	LSTAR	0.67	0	0
Qt-1, end-M2	ESTAR	LSTAR	0.67	0	0
Qt-1, mid-M3	ESTAR	LSTAR	0.67	0	0
Qt-1, end-M3	ESTAR	LSTAR	0.67	0	0
Nowcasts (in Qt)					
Qt, mid-M1	IndVar	LSTAR	0.67	-	-
Qt, end-M1	IndVar	LSTAR	0.67	-	-
Qt, mid-M2	IndVar	LSTAR	0.67	-	-
Qt, end-M2	IndVar	LSTAR	0.33	-	-
Qt, mid-M3	IndVar	LSTAR	0.33	-	-
Qt, end-M3	IndVar	LSTAR	0.33	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	Var	LSTAR	1.00	-	-
Qt+1, end-M1	Var	LSTAR	1.00	-	-

Notes: Alphabetical table entries are models: LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are: Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.

Table B.3.5. Exports

	Point forecasts	Density forecasts	Density forecasts (diagnostics)		
Criterion	Best model (RMSFE)	Best model (log score)	Tests for normality	Test for normality & independence	Tests for independence
Forecasts (before Qt)					
Qt-2, mid-M1	Var	ESTAR	0.33	0	0
Qt-2, end-M1	Var	ESTAR	0.33	0	0
Qt-2, mid-M2	Var	ESTAR	0.33	0	0
Qt-2, end-M2	Var	ESTAR	0.33	0	0
Qt-2, mid-M3	Var	ESTAR	0.33	0	0
Qt-2, end-M3	IndVar	ESTAR	0.33	0	0
Qt-1, mid-M1	IndVar	ESTAR	0.33	0	0
Qt-1, end-M1	Var	ESTAR	0.00	0	0
Qt-1, mid-M2	Var	ESTAR	0.33	0	0
Qt-1, end-M2	Var	ESTAR	0.33	0	0
Qt-1, mid-M3	Var	ESTAR	0.67	0	0
Qt-1, end-M3	Var	ESTAR	0.67	0	0
Nowcasts (in Qt)					
Qt, mid-M1	Var	ESTAR	0.33	-	-
Qt, end-M1	Var	ESTAR	0.33	-	-
Qt, mid-M2	Var	ESTAR	1.00	-	-
Qt, end-M2	Var	ESTAR	0.67	-	-
Qt, mid-M3	Var	ESTAR	0.67	-	-
Qt, end-M3	Var	ESTAR	0.67	-	-
Backcasts (after Qt)					
Qt+1, mid-M1	ESTAR	ESTAR	0.67	-	-
Qt+1, end-M1	ESTAR	ESTAR	0.33	-	-

Notes: Alphabetical table entries are models LSTAR is the logistic smooth transition autoregressive model; ESTAR is the exponential smooth transition autoregressive model. MS specifications are Ct switches in the intercept only, Ind switches in the indicator's coefficients only, Var switches in the variance only, CtVar switches in the intercept and variance, IndVar switches in indicator's coefficients and variance and AllVar is the general switching model; numerical table entries are percentages of tests not rejecting the null hypothesis (normality tests refer to Anderson-Darling, Kolmogorov-Smirnov and Jarque-Bera, joint normality and independence test refers to the likelihood ratio test proposed by Berkowitz, independence tests refers to the Ljung-Box independence test with lag 1, 2 and 3).

Source: authors' calculations.