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LEAST ANGLE REGRESSION FORECASTING AND THE PROBABILITY OF THE RECESSION

by Marco Buchmann

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Abstract

This paper aims at providing a detailed analysis of the leading indicator properties of corporate bond spreads for real economic activity in the euro area. In- and out-of-sample predictive content of corporate bond spreads are examined along three dimensions: the bonds' quality , their term to maturity, as well as the forecast horizon at which one intends to predict a change in real activity. Numerous alternative leading indicators capturing macroeconomic and financial conditions are included in the analysis.

Along with standard time series forecast models, the Least Angle Regression (LAR) technique is used to build multivariate models recursively. Models built via LAR can be used to produce forecasts and allow one to analyze how the composition and the number of relevant model variables evolve over time.

Corporate bond spreads turn out to be valuable predictors for real activity, in particular at forecast horizons beyond one year; Medium risk bond spreads with maturities between 5 and 10 years appear particularly rich in content. The spreads also belong to the group of indicators that implied the highest probability of a recession occurring from a pre-crisis perspective.

JEL classification: E32, E37, E44, G32

Keywords: Corporate bond spreads, point and density forecasting, automatic model building, least angle regression

Non-technical summary

Financial markets in the euro zone have, since the introduction of the common currency in 1999, developed and grown rapidly and this has been manifesting itself, inter alia, in the formation of a well-functioning area-wide corporate debt securities market. The formation of such market is thought of as being beneficial to the economy because it offers an important alternative source of finance and can eventually contribute to the overall stability of the financial system.

This study aims at analyzing the leading indicator properties of corporate bond spreads as well as that of numerous alternative macroeconomic and financial variables for real activity in the euro area. Assessing the information contained in corporate bonds, spreads relative to benchmark government bond yields respectively, both by means of in-sample analysis and by evaluating simulated out-of-sample point and density forecasts, allows testing the implications stemming from the financial accelerator theory, that is, whether the external finance premium on corporate bonds contains information on future real activity, which it should if it was reflective of risk that arises when investing in corporate debt.

From a methodological viewpoint, this paper intends to promote the use of a rather novel model building algorithm called Least Angle Regression (LAR). The purpose of the algorithm is to build a parsimonious multivariate model by selecting the most relevant set from a large number of potential indicator variables. LAR will be used recursively to re-build the multivariate model over a simulation period, with both the number and the composition of model variables being allowed to vary over time. The model that is built via LAR can in the sequel be used to generate out-of-sample point and density forecasts and is considered one competitor model. This approach also allows one to track what variables enter or leave the model in the course of the real time forecast exercise. Special emphasis lies on how macroeconomic and financial variables in general, and corporate bond spread variables in particular, rank over the period from right before to the outbreak and the aftermath of the financial crisis.

The empirical findings from this study can be summarized as follows: corporate bond spreads appear to contain valuable information for future real activity. In particular at horizons including and beyond 1 year, medium risk bond spreads appear among the most relevant predictors. In a multivariate model that comprises numerous alternative variables (including asset prices, various interest rates, the effective exchange rate, money growth measures, and volatility in equity markets), the AA corporate bond spread contributes the most to variation in output growth. A 1 standard deviation move in the spread is associated with a decline in growth of about -2.5 standard deviations over the following year. In terms of point, directional, and density forecast accuracy measures, the set of corporate bond spread variables outperforms the majority of alternative indicators. At the 1-year horizon, the model including the AA corporate bond spread reduces point forecast errors relative to a benchmark by about 21%, with the group of alternative indicators performing on average worse than the benchmark (by -6%).

The LAR approach, the recursively re-built multivariate models respectively, generate precise point and density forecasts. In particular at longer horizons, LAR outperforms the set of bivariate models and ranks first with regard to point, direction, and density forecast accuracy measures. At the 18-month horizon, it improves point forecast accuracy by about 30%, density forecast accuracy by 25%, and manages to predict close to 90% of the directions of change in output correctly.

Extracting probabilities for self-defined scenarios from the models' predictive densities sheds further light on the variables ability to foresee future developments in real activity: From a pre-crisis perspective (August 2007), models implying rather high probabilities of a recession for the year ahead include the A and AA corporate bond spread (both with a 7 to 10 year term remaining until maturity). The probability of a recession for the coming year implied by such models was ranging between 60%-70%, while all other bivariate models were implying recession probabilities of round about 30% on average.

1 Introduction

The potential of financial frictions to contribute to an amplification of business cycle dynamics has become apparent, undoubtedly, with the outbreak of the recent financial crisis and the subsequent downturn in real activity around the world. At least since Fisher (1933), a well-understood idea is that due to the nature of markets for external finance, which are characterized by frictions, e.g. as a result of asymmetric information, the availability of external finance to economic agents may be varying over time, and in particular may be shrinking during economic downturns, which in turn may cause a downturn to be worse than it would otherwise (in the absence of such frictions) be.

While in Fisher's view, the amplification of business cycle movements via financial frictions would be *asymmetric*, that is, limited to periods of contraction, the contemporary theory of the Financial Accelerator (FA) [see Bernanke et Al. (1999) and Bernanke and Gertler (1989)] envisages a *symmetric* mechanism, which is pro-cyclical in the sense that the strength of balance sheets tends to be positively correlated with the business cycle, i.e. it continues to hold during upturns. The key notion that the theory is based upon is the External Finance Premium (EFP) that is defined as the gap between the cost for external and the opportunity cost of internal finance, which is counter-cyclical as a result of its inverse dependence on the balance sheet strength and seen as reflective of various types of risks that arise when investing in corporate debt. It encompasses, inter alia, default and liquidity risk, and theory suggests that in particular the former should be affected by expected future macroeconomic conditions. Even if no frictions were present in the financial sector, the premium should have predictive content for real activity since it embeds the agents' perceived likelihood of default in the future. [1] [2]

Besides the role of the EFP for capturing, i.e. of it being merely *reflective* of expectations about (and therefore non-causal for) the future course of the economy, disturbances may as well *originate* in the financial sector, which may eventually trigger the business cycle to change its course [see e.g. Bernanke and Gertler (1990)]. Thus, in any case, and irrespective of the source of change or disturbance to financial conditions, the EFP is expected to anticipate changes in real activity.

The main difficulty that theorists but in particular empiricists are confronted with is that the EFP cannot be directly observed. Two approaches have emerged to address this issue: First, researchers have been seeking for directly observable proxies for the EFP; See e.g. Gertler and Lown (1999) and Mody and Taylor (2004). Levin et Al. (2004) follow a somewhat different approach: Unlike the former two references that rely on macroeconomic data, the authors employ micro-level data for 900 individual US companies to estimate a debt contract model that, in turn, leads them to derive the EFP and adduce evidence in favor of the hypothesis that financial frictions are present. Overall, according to this stream in the literature, corporate bond spreads can be seen as potential and valuable proxies for the EFP.

The second, alternative approach to address the EFP's unobservability has been to infer it from Dynamic Stochastic General Equilibrium (DSGE) models that embed financial frictions. De Graeve (2008) provides EFP estimates from a

[1] Along with the described channel through which the availability of credit, according to the FA theory, can impact growth indirectly via its effect on consumption and investment (i.e. through the non-financial sector), there have been attempts to explore a more direct role of the financial sector to amplify the business cycle: The notion of a New Financial Accelerator (NFA) has appeared [see Salleo and Santini (2009) and Adrian and Shin (2008)], which assigns a more direct role to financial institutions. Adrian and Shin (2008) argue that the NFA serves to amplify shocks to the business cycle mainly through leverage, which rises when asset prices fall. Banks need to liquidate assets in response to a negative asset price shock, which causes further downward pressure on asset prices. The NFA, like the FA, can be seen as a symmetric mechanism, i.e. it may as well reduce leverage in response to positive asset price shocks, and thereby let banks' assets expand. Leverage has, for the time being, not been included yet as a potential leading indicator in the present study.

[2] A more recent theoretical contribution to the literature is Philippon (2008) who relies on the q-theory of investment and shows that the bond markets q fits the investment equation much better than conventional measures of q; his model offers additional insight into why variation in corporate bond spreads should anticipate changes in real economic activity.

medium-scale DSGE model for the US; Gelain (2010) estimates a similar DSGE model for the euro area. The underlying DSGE models are adapted versions of those developed by Smets and Wouters (2003/2005) and Christiano et Al. (2005). Both authors compare their model-implied EFPs with some ready-to-use proxies, including e.g. credit standards [see also Lown and Morgan (2006)], debt to GDP ratios, and corporate bond spreads. The analyses reveal a high correlation of the model-implied EFP with corporate bond spreads: of up to 85% between AAA-rates bond spreads and the euro area EFP, and some 68%-86% between high-yield spreads and the model-consistent EFP for the US, depending on the timing of the correlation (from time-contemporaneous to a lead/lag of up to 4 quarters).

A recent contribution by Gilchrist et Al. (2009) has further renewed the interest in the particular role that corporate bond spreads play for serving as valuable proxies for the EFP. The authors construct a broad array of spreads from secondary market prices and give careful attention to the maturity structure of the bonds as well as to the default risk that is associated with the securities. They find strong evidence in favor of the hypothesis that a stable relationship between corporate bond spreads and different measures of real activity are present in the US. Intermediate risk bond spreads appear to perform particularly well, especially so at somewhat longer horizons. Mueller (2009) is the only other paper that I am aware of that envisages a comparable detailed breakdown of corporate bond spreads along the term structure and the risk dimension. He, too, finds that corporate bond spreads, when included in a forecasting model, provide predictions of US GDP growth that are comparatively accurate (in particular for the time of the recent financial crisis).

The question as to whether, and if so why, systematic differences in predictive content exist depending on the default risk associated with certain classes of corporate bonds, has been raised in Gertler and Lown (1999), and as well by De Graeve (2008) and Gelain (2010) who compare the model-implied EFP series with bond spreads for different classes of credit quality. With the exception of Gelain's (2010) findings, lower grade bond spreads are found to be better proxies for the EFP, to be more valuable predictors for real activity respectively. An argument for why below-investment grade bonds shall contain more valuable information is that high credit quality firms are not quite reflective of financial conditions of the overall economy, whereas lower quality firms are more likely to face the frictions that the theory envisages.

Research has been done as well on the empirical side, with regard to the role of asset prices in general, and corporate bond yields and spreads in particular. Stock and Watson (2003), who also provide a comprehensive review of the literature in this field, assess the role of asset prices by conducting short- and medium term forecast exercises, based on quarterly data for Canada, the US, UK, and other selected European countries. They find that asset prices are, during certain periods of time, useful indicators for future real activity (more than for price inflation). Forecast performance of single indicators, however, is relatively unstable over time. Additional evidence which is less supportive of significant predictive content being present in asset prices and therefore in line with Stock and Watson (2003), is adduced in Davies and Fagan (1997). Financial spreads, such as the spread between long and short term bond yields, the inverse yield gap, stock price returns, foreign bond yield differentials, and the like, do contain useful information for future activity. Similar to Stock and Watson, however, they find that model parameters are rather unstable and the authors argue that financial spreads cannot be used comprehensively as leading indicators for real and nominal macroeconomic variables. Mody and Taylor (2004) examine the information content in term spreads and high yield spreads and estimate long-horizon regressions. Their findings conform to those of other authors: Term spreads have lost their predictive power over time, whereas investment grade bond spreads continue to be useful leading indicators for real activity in the US.

Stock returns have been considered as a potential leading indicator for real activity (for a summary of the relevant literature see Stock and Watson (2003) and references therein). The empirical relationship between stock market prices and output or employment remains unstable, a result that De Bondt (2009) confirms for the euro area. He finds, however, that even though stock returns themselves contain less valuable information, their fundamental determinants, such as corporate earnings, equity risk premia, and the risk-free interest rate do help forecast real activity in the euro area and other industrialized countries.

Another vein in the literature has been concerned with the role of interest rates and their leading indicator and causal properties for real activity [see e.g. Bernanke and Blinder (1992)]. The general finding is that short-term policy rates do not improve the out-of-sample forecast accuracy of measures such as output growth as soon as it has been controlled for credit spreads. The slope of the yield curve, in particular, to which the literature also refers to as the term spread, has been given special attention and a considerable amount of theoretical work has been aimed at explaining why term spreads should have predictive content for economic activity; Examples are Stock and Watson (1989) and Estrella and Hardouvelis (1991). Empirical studies have found that term spreads have predictive content for output growth in the US, particularly at short horizons. Fama (1990) and Mishkin (1990) seem to confirm these results[3].

Additional indicators for real activity whose role will be examined in this study are the effective euro exchange rate and the price of oil. Exchange rates have been considered a potential leading indicator for price inflation since they are seen as a channel through which inflation can be imported from countries with which one engages in trade [see e.g. Gordon (1998)]. Concerning output growth, only very few studies exist that address the information contained in exchange rates, and those that exist, such as Stock and Watson (1999), suggest that they do not seem to contain information that would be useful for forecasting real activity. The predictive content of the price of oil has been analyzed, e.g., in Haltmaier (2008) who finds that the oil price has predictive power for recessions in the US. Similar conclusions were drawn by Engemann et Al. (2010) who employ a time-varying parameter Probit model.

Apart from theoretical and empirical work that addresses the role of asset prices in general, research has also been looking at the particular role of corporate bond spreads and their predictive content for real activity. Gertler and Lown (1999) find that high-yield spreads have significant forecast power for the US business cycle. Models that contain corporate bond spreads outperform others that involve term spreads, paper-bill spreads, or the FED funds rate. Further empirical evidence has been provided by Chan-Lau and Ivaschenko (2001) who find that investment-grade bond spreads anticipate changes in industrial production in the US with a lead time of up to 12 months[4].

[3] See also Friedman and Kuttner (1992), Plosser and Rouwenhorst (1994), Kozicki (1997), Estrella and Mishkin (1998), Harvey (1989), and Laurent (1989), Duca (1999), Stock and Watson (2002), Bordo and Haubrich (2004), and Espinoza et Al. (2009). Some authors have shown that the predictive content of term spreads has become weaker over time: see e.g. Dotsey (1998), Chauvet and Potter (2002/2005), Giacomini and Rossi (2006), and Wright (2006).

[4] See also Guha and Hiris (2002), King et Al. (2007), Mueller (2009), and Fornari and Lemke (2010). Fornari and Lemke (2010) combine a Probit model for capturing the dynamics of a discrete expansion/recession indicator with a VAR model to endogenize the otherwise exogenous predictors in the Probit model. The authors find that the measure of the slope of the yield curve contains valuable information for predicting recession probabilities. Their list

For the euro area, work that considers explicitly the role of corporate bond spreads has so far been rather limited. De Bondt (2002, 2004, 2005) has provided first empirical evidence that confirms a strong role of corporate bond spreads for forecasting real activity. De Bondt analyzes both the determinants and the leading indicator properties of corporate spreads for short- and long maturities and finds, inter alia, that spreads lead changes in industrial production, industrial confidence, and to a lesser extent real GDP. Apart from information contained in bond yields, the paper also investigates whether quantities correlate with real activity either contemporaneously or with some lag and the results suggest that issuance is positively related to mergers and acquisitions and the measure of industrial output.

At the time when De Bondt presented empirical results in 2002/2004, the euro area corporate bond market was still relatively young and the sample of data that could be employed was necessarily short, the results in the sequel rather preliminary. Meanwhile, the area-wide market for corporate debt has developed much further, and longer series of data for bond yields are available. The present study intends therefore to contribute to the literature by providing a detailed empirical analysis of the leading indicator properties of corporate bond spreads for real economic activity in the euro area. Similar to the analysis in Gilchrist et Al. (2009) and Mueller (2009) for the US, a detailed breakdown of corporate bond spreads along the term structure as well as the risk dimension will be provided.

A rather novel model technique is applied in this paper: the so-called Least Angle Regression (LAR) [see Efron et Al. (2004)]. The model building algorithm is an alternative to more traditional techniques such as Forward Selection, Forward Stagewise, or Backward Elimination methods. The functioning of the LAR will be modified for the sake of its use in the present forecast context. Details on how the algorithm works, along with other benchmark models, will be presented in Section 2.

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of predictors includes, inter alia, also the short-term interest rate stock market indices and a corporate bond spread variable which appear to contain information beyond those that are contained in the term spread. De Bondt and Hahn (2010) develop a new monthly indicator for real activity in the euro area using a deviation cycle methodology. The new measure has good indicator properties and leads the euro area business cycle by about 6 months.

2 Econometric methodology

2.1 The model suite

Towards the assessment as to how real activity and the set of macroeconomic and financial variables interact, both in- and out-of-sample analyses are going to be conducted. At the heart of all exercises lies a direct-step forecast model that has the following format.

$$\frac{1200}{h} \cdot \ln\left(\frac{y^{IP}_{t+h}}{y^{IP}_{t}}\right) = \alpha_0 + \sum_{i=0}^{P} \alpha_{i+1}\left[\frac{1200}{h} \cdot \ln\left(\frac{y^{IP}_{t-i}}{y^{IP}_{t-i-h}}\right)\right] + \sum_{k=1}^{K} \beta_k x^k_t + \epsilon_{t+h} \quad (1)$$

where y^{IP}_{t+h} is the area-wide industrial output in levels. The model is allowed to comprise up to $P+1$ autoregressive lags and as well one or a group of K additional exogenous variables x^k_t. The error term is assumed to be independently and identically distributed. Based upon this general model specification, various routes are then being followed.

First, the model is used to produce in-sample estimates at various horizons ($h = 1, 3, 6, 12, 15, 18$ months). To measure in-sample performance, the adjusted R-square will be employed. The lag structure of the model for a given sample will be determined using the Bayesian Information Criterion (BIC). A univariate model having the optimal number of lags, yet excluding any further covariates by constraining all β_k to zero will be considered a benchmark. All bi- and multivariate models will have the same optimal number of lags so as to allow a fair judgment of the information that additional covariates may contain.

The in-sample analysis will be accompanied by an out-of-sample forecast simulation. To this end, the same direct-step forecast model will be used. A number of model variants will then be considered for forecasting. They include the following:

i. **RWD**: In model (1), the α_0 is estimated, α_1 is set to 1, and all $\alpha_2, ..., \alpha_{P+1}$, and $\beta_1, ..., \beta_K$, are constrained to zero. Model (1) therefore reduces to a Random Walk with Drift (RWD).

ii. **UNI**: Model (1) is allowed to contain the constant and the optimal number of autoregressive lags but no further covariates, that is, all $\beta_1, ..., \beta_K$ are set to zero. This model is referred to as univariate (UNI).

iii. **BI**: The univariate model with the optimal number of lags is augmented with all indicator variables (one after another). These models are referred to as bivariate (BI).

iv. **LAR**: Model (1) is linked to the LAR algorithm. Details follow in Section 2.2 below. The algorithm builds multivariate models recursively, so that the number and the composition of model variables can change over time. Irrespective of the model's composition, it comprises as well the optimal number of autoregressive lags.

Note that the bivariate and LAR models are set up such that y_{t+h}^{IP} is related time-contemporaneously to one or a set of x_t^k, that is, no further lags of the indicator variables are allowed to enter the model. Additional lags could, in principle, be allowed to enter but I refrain from doing so for two reasons: 1) the aim is to analyze precisely for what horizons respective indicator variables have predictive content; including a first or higher lags would aggravate the interpretation of the forecast evaluation results because one could not be sure whether increased precision, say, at the 1-month forecast horizon was due to variation in x one or two or more periods ago; 2) given that the LAR algorithm will let a multiple of indicator variables enter the model, the models' dimension should not be further increased by adding additional lags.

2.2 Least angle regression and recursive model building

Augmenting a univariate model with additional covariates one after another is a meaningful first attempt at revealing a variable's importance for improving model performance in- and out-of-sample. It is not, however, fully satisfactory an approach since one would want to combine covariates, i.e. build truly multivariate models.

A method that is particularly well suited for dealing with large collections of model variables is the Least Angle Regression (LAR) approach [Efron et Al. (2004)]. The LAR algorithm is described in the following (for some technical details that are omitted I refer to the original paper by Efron and coauthors).

After having explained the basic LAR mechanism it will be made clear how it is linked to the direct-step model set-up described in the previous section.

LAR builds upon a linear projection of $\mathbf{y}$ onto $\mathbf{X}_{\mathbf{A_k}}$, where $\mathbf{y}$ is a vector holding the dependent variable and $\mathbf{X}_{\mathbf{A_k}}$ is the *active set* comprising a group of covariates at step k. The idea of LAR is to let additional covariates enter the active set sequentially and the sequence as such will signal the importance of covariates for explaining variation in $\mathbf{y}$. Note that $\mathbf{y}$ and all covariates contained in $\mathbf{X}_{\mathbf{A_k}}$ shall be provided to LAR in normalized format, that is,

$$\sum_{t=1}^{T} y_t = 0,\ \sum_{t=1}^{T} x_t^k = 0 \text{ and } \sum_{t=1}^{T} \left[\left(x_t^k\right)^2\right] = 1 \text{ for all } k = 1, ..., K \tag{2}$$

With the active set $\mathbf{X}_{\mathbf{A_k}}$ at hand, one then proceeds as follows. Construct two matrices $\mathbf{V}$ and $\mathbf{A}_{\mathbf{A_k}}$,

$$\mathbf{V}_{A_k} = \mathbf{X}_{A_k}^T \mathbf{X}_{A_k} \text{ and } \mathbf{A}_{A_k} = \left(\mathbf{I}_{A_k}^T \mathbf{V}_{A_k}^{-1} \mathbf{I}_{A_k}\right)^{-1/2} \tag{3}$$

where $\mathbf{I}_{A_k}$ is a column vector of 1's whose length is equal to the number of covariates in the current active set. Then, an equiengular vector $\mathbf{u}_{A_k}$ can be constructed, that is,

$$\mathbf{u}_{A_k} = \mathbf{X}_{A_k} \mathbf{A}_{A_k} \mathbf{V}_{A_k}^{-1} \mathbf{I}_{A_k} \tag{4}$$

With these preliminary definitions, the sequential algorithm can now be described as follows: the LAR procedure starts with an empty active set, thus rendering the fit at that first stage a column vector of zeros since a constant is absent (variables have been standardized). Denoting the fit at that first stage as $\mathbf{f}_{A_0}$, or at some later stage as $\mathbf{f}_{A_k}$, one then constructs a vector $\widehat{\mathbf{c}}$,

$$\widehat{\mathbf{c}} = \mathbf{X}^T \left(\mathbf{y} - \widehat{\mathbf{f}}_{A_k}\right) \tag{5}$$

which is referred to as the vector of *current correlations*. From $\widehat{\mathbf{c}}$, the maximum absolute current correlation can be identified, that is,

$$\widehat{\mathbf{c}}_{\max} = \max_j \left\{|\widehat{c}_j|\right\} \tag{6}$$

The set $\mathbf{X}_{A_k} = (s_j \mathbf{x}_j \cdots)$, the collection of covariates in the active set, has objects s_j either equalling plus or minus one that signal whether the current correlation $\widehat{c}_j$ is positive or negative. The final step is now to produce an update $\widehat{\mathbf{f}}_{A_{k+1}}$ of the fit vector by referring to the inner product of $\mathbf{X}$ with $\mathbf{u}_{A_k}$.

$$\widehat{\mathbf{f}}_{A_{k+1}} = \widehat{\mathbf{f}}_{A_k} + \widehat{\mu}\mathbf{u}_{A_k} \tag{7}$$

The value of $\widehat{\mu}$ is minimized and chosen so as to let the next covariate enter the active set. That is,

$$\widehat{\mu} = \overset{+}{\min_{j \in \mathbf{A}_k}} \left\{ \frac{\widehat{\mathbf{c}}_{\max} + \widehat{c}_j}{\mathbf{A}_{A_k} - (\mathbf{X}^T \mathbf{u}_{A_k})}, \frac{\widehat{\mathbf{c}}_{\max} - \widehat{c}_j}{\mathbf{A}_{A_k} - (\mathbf{X}^T \mathbf{u}_{A_k})} \right\} \tag{8}$$

Steps (5) to (8) can then be followed recursively with one additional covariate entering the active set at each step. After K steps, the active set comprises all covariates that have been provided to LAR and the algorithm comes to an end.

In order to have also an intuitive understanding of the algorithm, let us summarize the steps that it involves.

i. First, the dependent and independent variables should be normalized so that they have unit length and variances (the latter only for covariates).

ii. The algorithm starts by identifying the covariate x_j whose correlation with the current residual vector $\mathbf{r} = \mathbf{y} - \widehat{\mathbf{f}}$ is the highest and allows this variable to enter the active set first. Note that in the first round when the active set is yet empty, $\widehat{\mathbf{f}} = \overline{\mathbf{y}} = 0$, i.e. the fit equals the average of the $\mathbf{y}$ which is zero since it has been normalized.

iii. The current correlation between the residual vector and the set of remaining covariates that have not yet entered the active set can be computed.

iv. The coefficient vector is steered towards the OLS estimate of a regression involving the x_j and the residuals. The covariate that has just entered the active set is not allowed to 'fully' enter the model but only as much as is necessary to render its own correlation with the current residual *equal* the correlation between the residual and a next competitor variable.

v. The next competitor is allowed to enter the active set. Fit and residuals are produced based on the model that now has one additional covariate.

vi. Loop over steps (iii)-(v). In Step (iv), since more than one variable is contained in the active set, it is now a vector of coefficients whose elements are *jointly* moved into the direction of their least-squares estimates. This movement, again, pauses as soon as the current correlation will equal the correlation between a non-active variable and the current residuals.

Akin the LAR algorithm is another shrinkage method called LASSO [Tibshirani (1996)][5]. Minor modifications of the LAR in fact lead to the LASSO algorithm [for details see Efron et Al (2004)]. Comparing the LAR with the LASSO methodology helps furthering the understanding of why the LAR is such an efficient model selection approach: The main difference between the two is that LASSO, while following the same step-wise approach in principle, moves the vector of coefficients at stage (iv) continuously in small incremental steps (in practical applications the procedure may involve some 5,000-10,000 steps). This procedure is sometimes referred to as *soft-thresholding*. LAR turns out to be more efficient because it does not move successively but in fact can foresee the distance it should move in step (iv). The sequence of variables entering a model that is inferred from LAR and LASSO tend to be identical; the computational cost of finding this sequence, however, differs markedly: LASSO may need 10,000, while LAR involves K steps, hence making the computational cost of the latter identical to that required by ordinary least squares.

To assemble the direct step forecast model presented in (1) with the LAR algorithm, one final mechanism which concerns the autoregressive lags of the model is being implemented. In principle, lags of the endogenous variable could be considered potential covariates, just as the set of exogenous variables, from which LAR can then select. The optimal sequence may in this case be such that other exogenous variables enter first, autoregressive lags may enter sooner or later, and it may also happen that higher lag numbers enter before lower ones. In the following, the LAR is modified such that autoregressive lags will in fact not be provided to LAR and follow a route that Efron et Al. (2004) refer to as *main effects first*. The idea is that the univariate model, with an optimal

[5]The rationale behind LASSO is very similar to that of a RIDGE regression [Hoerl and Kennard (1970)]. The idea of these shrinkage methods is to constrain the sum of the model's coefficients to a value that shall be smaller than the sum of the unconstrained OLS estimates. While in a RIDGE regression the sum of the *squared* coefficients is constrained, the LASSO restricts the sum of the *absolute* coefficient values.

number of lags is estimated first and then their residuals are passed on to the LAR algorithm. This is to ensure that all variation in the dependent variable that can be explained by its own past has already been filtered out before letting LAR judge the importance of additional covariates. As far as the left-hand-side variable, the current residual **r** in step (i) is concerned, the first expression in equation (2) respectively, no initial standardization is in fact necessary because the univariate model's residuals have zero mean by construction (even if BIC has chosen zero lags because at least a constant remains).

The optimal number L^* of the ranks that LAR has identified is determined via the BIC, just as the number of autoregressive lags. Note that L^* can equal any value between $0, 1, ..., K$. There is no restriction that would force a number of LAR ranked variables into the model. To compute the BIC, the univariate models (that possibly already contain a number of autoregressive lags) are augmented step-by-step with one additional covariate, following the sequence that LAR considers optimal. This step-wise procedure refers to a set of K models, with its dimension increasing by one at each step. The maximum dimension of the model is therefore given by $K + 1 + P^*$, where P^* is the optimal number of autoregressive lags.

After all, the LAR methodology, when used in a recursive fashion, allows tracking how the composition of model variables that explain variation in output evolves over time. Both the number and the set of variables as identified by LAR are allowed to vary. To my knowledge, the LAR technique has not yet been used for the purpose of out-of-sample forecasting from recursively re-selected models[6].

2.3 Point and density forecasting and forecast evaluation

All models are re-estimated and solved recursively using an expanding window scheme, starting with a sample that initially covers the period from January 1995 until December 2003. The first one-step ahead forecasts are generated for January 2004. The models are used to produce a set of h-step-ahead predictions, will be provided with new data, be re-estimated and then generate a new set of forecasts. This process is repeated recursively until the end of the sample. The

[6]The related LASSO model selection technique appears not to be widely used in empirical macroeconomics either. A paper by Schneider and Wagner (2009) is an exception: from a large set of potential indictor variables, the authors aim to identify relevant explanatory variables for economic growth.

in-sample period for model forecasts at horizons h exceeding one is adjusted so as to end h periods prior to January 2004. The number of simulated forecasts is therefore the same across all forecast horizons. The lag structure of the models is re-optimized based on the BIC at every point in time (the maximum number of lags from which BIC chooses is set to 3).

Simulated point forecasts from the RWD, UNI, BI, and LAR models are evaluated based on Root Mean Square Forecast Errors (RMSE) as well as a measure of directional accuracy, namely the percentage of correctly predicted Directions of Change (DC) over the test period. The DC measure is applied to the *level* prediction, meaning that for the format in changes as in model (1), computing the DCs involves merely a sign check. The DC signals how good the models perform at predicting turning points in the level of output correctly.

To judge whether differences in RMSE relative to the RWD (the benchmark) are significant from a statistical point of view, the RMSE are accompanied by a Clark-West (2007) test statistic.

Density forecasts from all models are generated via a standard nonparametric bootstrap method that re-samples with replacement from a model's residuals that are available at the time when a forecast is made. Their distribution is then centered on a point forecast for a given horizon. In order to then assess how accurate the models' predictive densities are, the Continuously Ranked Probability Score (CRPS) will be used[7]. The function has the following form.

$$s_{t+h}^{M} = \int_{-\infty}^{+\infty} \left(\int_{-\infty}^{R_{t+h}} f_{t+h|t}^{M} \left(R \right) dR - I \left(R \geq R_{t+h} \right) \right)^{2} dR \tag{9}$$

where the score s_{t+h}^{M} is a function of the realization R_{t+h}, that is, the left-hand-side variable from equation (1), $f_{t+h|t}^{M}$ is the predictive density from one of the models $M = \{RWD, UNI, LAR, BI\}$, and $I(\cdot)$ is an indicator that is one if the condition in parentheses is true and zero otherwise. The score can then be averaged over the out-of-sample test period and be reported for all models.

[7] See e.g. Matheson and Winkler (1976) and Gneiting et Al. (2007).

3 Data

For the purpose of the empirical analysis of this paper, economic activity is measured by growth in euro area industrial production (IP). The corporate bond yield series are provided by Merrill Lynch and are available for a variety of rating class / maturity combinations. Rating classes include AAA, AA, A, BBB and below; Maturities range from 1-3, 3-5, 5-10, 7-10, and more than 10 years. Overall, there are 19 different rating class / maturity combinations for which time series are available at monthly frequency back until December 1995. The corporate bond indices refer to euro denominated investment grade corporate debt that is publicly issued in euro domestic markets.

Securities have to fulfill a number of criteria in order to qualify for their inclusion in the index: they need to have an investment grade rating (Merrill Lynch computes a composite rating based on an average of three rating agencies: Moody's, S&P, and Fitch), must have at least one year remaining until final maturity and should have an amount outstanding of at least EUR 250 million. The indices cover the financial sector (banks and insurance companies), utility and industrials[8]. Bond spreads are then calculated from corporate bond yields and the relevant benchmark government bond yield series, where the latter are available for maturities ranging from 1 up to 10, 15, 20, and 30 years. Government bond yields are averaged for respective maturities prior to the construction of spreads. As an example, to construct the spread series for AAA-rated bonds with 1-3 years maturity, government bond yields for 1, 2, and 3 years maturity are first averaged and then used to calculate the spread.

All variables that are initially available at some frequency higher than monthly, e.g. the yield curve variable (spread between 3-month Euribor and 10 year benchmark government bond yield), the Dow Jones Eurostoxx 50 index, and the price of Brent crude oil (1-month forward), for all of which daily data are available, are converted to monthly frequency by taking period averages. The measure of industrial confidence (provided by the European Commission) is available at monthly frequency and has not to be further converted. Monetary aggregates (M1, M2 and M3) are retrieved from ECB databases in the form

[8]Industrials include the following sub-sectors: automotive, basic industry, capital goods, consumer cyclical and non-cyclical, energy, healthcare, media, real estate, services, technology, electronics, and telecommunications. A complete sector classification and more detailed information on the construction of the index and the rating algorithm are available on Bloomberg.

of indexes of notional end-of-period stocks from which percentage changes are computed.

The set of covariates also includes three realized volatility measures which are based on the USD-EUR exchange rate, the short-term interest rate, and the Dow Jones Eurostoxx50 index. These variables are meant to be indicators of volatility in three broad segments of the economy: the foreign exchange market, interbank money markets and equity markets. The three series initially had a daily frequency based upon which realized volatilities using a rolling window of 30 days were computed. A monthly frequency was obtained again by taking period averages.

One survey indicator deserves special emphasis: the 'dispersion in expectations' (DI_EX) variable is constructed based on five individual answer shares to Question 6 from the European Commission's Consumer Survey (for details on how the variable is computed see Annex 1). The DI_EX variable is constructed such that it ranges between zero and one, with these two bounds referring to full agreement and full disagreement as to how prices develop in the future. Even though a measure of dispersion in expectations with regard to future *real* activity would have been a somewhat better choice, the dispersion measure related to expected nominal activity will be included in the analysis for at least two reasons: first, a detailed breakdown of answer shares in response categories that allows computing a dispersion measure is available only for price expectations; second, uncertainty about future price developments may serve as a proxy for a broader kind of uncertainty about future economic conditions[9].

Annex 1 contains an overview of how all variables are pre-processed prior to their use in the forecast models. Some of the model variables are included more than once, with different transformation settings applied, that in particular concern the number of periods over which percentage changes or log differences are computed. In the following, when referring to such variables, the relevant setting will be stated in parentheses; e.g. '($\Delta 3$)' means we consider a change in a variable over 3 months. Annex 1 shows whether it is logarithmic, plain, or exact percentage changes that have been applied to respective model variables

[9] See also Badarinza and Buchmann (2010, forthcoming). This paper aims at demonstrating that changing levels of aggregate disagreement influence the propensity of the economy to switch between different growth regimes (evidence for the US). The rationale is that higher levels of agreement render the economy more vulnerable to exogenous shocks and therefore make a transition to lower-growth regimes more likely.

(if any). After all, there are a total of 37 potential leading indicators whose information content for real activity can be assessed.

4 In-sample analysis

4.1 Ranking based on bivariate models and LAR

All rankings referred to in this section are based on either the adjusted R-square measures from the BI models or from the sequence of variables that LAR has identified. The inference of ranks from the LAR procedure is different from that based on BI models because the LAR models become multivariate, increasingly so as one follows the sequence from highest to lowest ranks. If there appears a rank, say 25, for a model variable, then the LAR approach has at this point built a 25-dimensional model (plus possibly a number of autoregressive lags).

Table 1 below is a reduced summary of the in-sample rankings of model variables reported in Table 7 and 8 (see Annex 2). Table 1 narrows the ranks down to the first five out of 37 and it reports them only for the 1, 6, 12, and 18-month horizons.

The results for the *pre-crisis* period, with focus on the BI model rankings, can be summarized as follows.

- The stock price variables ($\Delta 3$ and $\Delta 12$) attain the highest ranks at the 1-month horizon.
- At the 6-month horizon, the dispersion in expectation variable ranks first.
- At longer horizons ($H = 12$ and $H = 18$), variables occupying the first ranks are M1 ($\Delta 12$), DI_EX, and the BBB spread (5-10y maturity). The latter exerts a stable performance across horizons: For the 12 and 18 month horizon it ranks third.
- M1 ($\Delta 12$) is the only variable that explains more than 50% of variation in output at the 1-year horizon.
- At the longest horizon ($H = 18$), DI_EX still explains 47%, M1 ($\Delta 12$) about 43%, and the BBB spread (5-10y) about 38% of variation in output over that horizon.

Considering instead the *full sample* including the crisis period until December 2009, the relative importance of indicator variables changes as follows.

Table 1: Summary in-sample analysis (top-5 ranks)

	Pre-Crisis Period (Jan 1999 - Dec 2007)							
	BI-MODELS				LAR			
Rank / Horizon	1	6	12	18	1	6	12	18
1	STOX (Δ12)	DI_EX	M1 (Δ12)	DI_EX	STOX (Δ12)	DI_EX	M1 (Δ12)	DI_EX
2	STOX (Δ3)	M1 (Δ12)	DI_EX	M1 (Δ12)	STOX (Δ3)	M1 (Δ12)	DI_EX	M1 (Δ12)
3	RV_STOX50	STOX (Δ3)	BBB_5_10	BBB_5_10	M2 (Δ3)	STOX (Δ3)	BBB_5_10	BBB_5_10
4	OIL (Δ12)	BBB_7_10	A_5_10	A_5_10	RV_STOX50	BBB_7_10	OIL (Δ3)	LTN
5	BBB_1_3	BBB_5_10	LTN	BBB_3_5	OIL (Δ3)	M2 (Δ12)	LTN	M3 (Δ12)
	Full Sample Period (Jan 1999 - Dec 2009)							
	BI-MODELS				LAR			
1	AAA_1_3	AA_5_10	DI_EX	BBB_5_10	STOX (Δ3)	M1 (Δ12)	DI_EX	BBB_5_10
2	A_5_10	AA_7_10	A_7_10	M1 (Δ12)	RV_STOX50	AA_5_10	A_7_10	M1 (Δ12)
3	AA_3_5	A_5_10	M1 (Δ12)	A_5_10	YIELDC	DI_EX	M1 (Δ12)	LTN
4	A_7_10	A_7_10	A_5_10	BBB_3_5	M2 (Δ3)	YIELDC	AA_1_3	DI_EX
5	STOX (Δ3)	AA_3_5	AA_7_10	LTN	AAA_1_3	OIL (Δ12)	OIL (Δ12)	A_5_10

Note: Cells holding corporate bond spread variables are shaded in gray.

- For horizons below 12 months, the corporate spread variables occupy the highest ranks: at the 1-month horizon, AAA (1-3y) ranks first, followed by the A spread (5-10y) and AA (3-5y).
- At horizons equal and beyond 12 months, the DI_EX variables obtains the first rank, followed by the A spread (7-10y) and M1 ($\Delta 12$). At the longest horizon ($H = 18$), the BBB (5-10y), M1 ($\Delta 12$), and again the A spread (5-10y) rank first to third.
- The maximum variation in output at the 6-month horizon is explained by AA spreads (5-10y); The adjusted R-square approaches 66%. At the longest horizon, the BBB spread can explain some 36% of variation in output.

Starting anew by referring to the *pre-crisis* sample period, the findings from the LAR model selection procedure can be summarized as follows.

- M1 growth ($\Delta 12$) attains first and second ranks at all horizons beyond and including 6 months.
- Stock price variables ($\Delta 3$ and $\Delta 12$) attain first, second, and third ranks at the 1- and the 6-month horizons.

- The dispersion in expectations variable never ranks worse than third beyond the 3-month horizon.
- Among the corporate bond spread variables, the high-yield spread (BBB, 5-10y) appears strongest in explaining variation in output at horizons beyond one year. The variable ranks third, second, and third for $H = 12, 15, 18$.

Full-sample estimates and corresponding LAR rankings for the models suggest:

- M1 growth ($\Delta 12$) again occupies the first three ranks, now at all horizons at and beyond 3 months.
- Stock prices ($\Delta 3$) still perform well at the shortest horizon ($H = 1/H = 3$).
- At the 1-year horizon, the dispersion in expectations variable ranks first.
- Medium-risk (AA, 5-10y) corporate spreads perform well at the 6-month horizon. The BBB spread (5-10y) ranks first at the longest horizon ($H = 18$).
- Long-term interest rates now rank third at the 18-month horizon.

Apart from the actual selection and ordering of indicator variables, the optimal number of LAR ranks to be included in the models across different horizons can be examined (see Table 7 and 8): for the reduced-sample 1-step ahead model, the first three ranks (stock prices with $\Delta 3$ and $\Delta 12$, as well as M2 ($\Delta 3$)) enter the model. At the 6- and 12-month horizon, there are already 10 variables entering the model; when further increasing the horizon, some 20 covariates enter for $H = 15$, and 15 variables when the horizon was set to $H = 18$. A similar pattern can be seen when looking at full-sample LAR model results. The model contains five variables at the 1-month and 22 at the 15-month horizon.

4.2 Estimation results for selected LAR models

Table 2 and 3 show in-sample estimation results for the pre-crisis and the full sample for selected multivariate models at the $H = 3$ and $H = 12$ month horizon. The composition and number of variables included in these models is set as suggested by the LAR algorithm and the order of the variables as they appear in the result tables corresponds to respective LAR sequences.

Short-term variation in output over one quarter for the pre-crisis period appears to be anticipated mainly by variation in stock prices, the level of dispersion in expectations, and movements in oil prices. From a statistical point of view, the effect of stock price changes ($\Delta 3$) turns out to be most significant (p-value=0.0003). Also from an economic perspective, stock prices ($\Delta 3$) seem to be associated with the strongest response in output compared to the remaining model variables: a 1 standard deviation (STD) 1-quarter change in stock prices induces a +0.37 STD move in output one quarter ahead.

As regards the full-sample estimates ($H = 3$), the set of covariates as identified by LAR is now somewhat broader; the yield curve variable, M1 growth ($\Delta 12$), and AAA corporate bond spreads (1-3y) enter the set of covariates. Along with the first autoregressive lag, all these variables except for the yield curve variable turn out to be significant at conventional levels. A 1 STD move in the corporate bond spread causes the strongest reaction in output one quarter ahead, with the corresponding standardized coefficient equaling -0.48 STD. A stock price move by 1 STD over one quarter is to result in a +0.48 STD movement in output the following quarter. A 1 STD move in money growth entails a +0.34 STD reaction in output one quarter ahead.

When considering instead the model for $H = 12$ (Table 3), the LAR suggests that both the reduced and the full-sample model shall comprise more model variables than the $H = 3$ model. Based on the pre-crisis sample of data, the following variables turn out to have significant impact upon output growth (sign of effects in parentheses): dispersion in expectations (+), CBS BBB (5-10y) (-), M2 ($\Delta 12$) (+), oil ($\Delta 12$) (+), industrial confidence (-), and the AA corporate bond spread (10-30y) (+). Standardized coefficient estimates suggest that the BBB (5-10y) corporate spread is the variable that causes the strongest reaction in output (-0.55 STD), followed by industrial confidence (-0.53 STD) and annual changes in the price of oil (+0.51 STD).

The $H = 12$ model based on the full-sample of data is the one that comprises the largest number of explanatory variables (20 plus constant). Eight out of these 20 variables are significant at least at the 10% level. The effect of four variables turns out to be significant at the 1% level: the A (7-10y) (+), AA (7-10y) (-), AAA (3-5y) (+) spreads and the real effective exchange rate ($\Delta 12$) (-). The AA spread (7-10y) causes the strongest reaction in YoY output growth: a 1 STD move in the spread induces a fall in output by about -2.5 STD a year ahead. It is somewhat surprising that the effects of some of the spread variables have been estimated with such high precision given their high positive correlation (the correlation between A and AA spreads (both 7-10y), e.g., approaches 97% full sample).

Table 2: In-sample estimation results, Horizon = 3 months

Dependent Variable: Y = (IP(+3) - IP) / IP *100

Pre-Crisis Period (Jan 1999 - Dec 2007)						
Included observations: 104 after adjustments						
Variable	Coefficient	Std. X	Coefficient*	Std. Error	t-Statistic	Prob.
C	-6.54	0.00	0.00	2.61	-2.51	0.0138
STOX (Δ3)	0.04	9.50	0.37	0.01	3.79	0.0003
STOX (Δ12)	0.01	23.99	0.18	0.00	1.75	0.0835
DI_EX	12.21	0.02	0.26	4.55	2.68	0.0085
OIL (Δ3)	0.01	15.80	0.12	0.01	0.89	0.3742
R-squared	0.4322		Mean dependent variable			0.5546
Adjusted R-squared	0.4092		Std. dependent variable			0.8992
S.E. of regression	0.6912		Akaike info criterion			2.1460
Sum squared resid	47.2921		Schwarz criterion			2.2731
Log likelihood	-106.5912		F-statistic			18.8373
Durbin-Watson stat	1.3606		Prob(F-statistic)			0.0000

Full Sample Period (Jan 1999 - Dec 2009)						
Included observations: 128 after adjustments						
Variable	Coefficient	Std. X	Coefficient*	Std. Error	t-Statistic	Prob.
C	-0.37	0.00	0.00	0.32	-1.15	0.2527
Y(-1)	0.60	1.86	2.09	0.10	5.77	0.0000
STOX (Δ3)	0.02	10.63	0.48	0.01	2.40	0.0179
YIELDC	-0.19	0.95	-0.33	0.13	-1.39	0.1675
M1 (Δ12)	0.05	3.71	0.34	0.02	2.00	0.0477
AAA_1_3	-0.62	0.41	-0.48	0.34	-1.80	0.0751
R-squared	0.7974		Mean dependent variable			0.0477
Adjusted R-squared	0.7890		Std. dependent variable			1.8659
S.E. of regression	0.8570		Akaike info criterion			2.5750
Sum squared resid	89.6025		Schwarz criterion			2.7087
Log likelihood	-158.7987		F-statistic			96.0074
Durbin-Watson stat	1.7247		Prob(F-statistic)			0.0000

Note 1: *Std. X* is the standard deviation of explanatory variables for the relevant sample period.
Note 2: *Coefficient* is the* normalized coefficient (Coefficient* = Coefficient .* Std.X ./ Std. dependent variable)
Note 3: In the *Coefficient** column -- Orange, dark grey and light grey indicate the 1st three ranks based on the absolute value of standardized coefficients.
Note 4: In the *Prob.* column -- Orange shaded cells - significant at 1% level, dark grey: 5%, light grey: 10%. Standard errors are heteroskedasticity robust (Newey-West).

Table 3: In-sample estimation results, Horizon = 12 months

Dependent Variable: Y = (IP(+12) - IP) / IP *100

Pre-Crisis Period (Jan 1999 - December 2007)

Included observations: 95 after adjustments

Variable	Coefficient	Std. X	Coefficient*	Std. Error	t-Statistic	Prob.
C	-19.15	0.00	0.00	3.51	-5.46	0.0000
M1 (Δ12)	-0.05	3.19	-0.07	0.07	-0.71	0.4783
DI_EX	36.61	0.02	0.31	6.11	5.99	0.0000
BBB_5_10	-2.57	0.47	-0.55	0.34	-7.51	0.0000
OIL (Δ3)	-0.01	16.33	-0.05	0.01	-0.70	0.4855
LTN	-0.40	0.69	-0.12	0.25	-1.62	0.1079
M2 (Δ12)	0.45	1.37	0.28	0.17	2.69	0.0087
AAA_3_5	-0.54	0.14	-0.03	1.00	-0.54	0.5914
OIL (Δ12)	0.03	32.57	0.51	0.01	4.91	0.0000
CO_IN	-0.20	6.06	-0.53	0.03	-6.96	0.0000
AA_10_30	2.16	0.26	0.25	0.78	2.79	0.0065
R-squared	0.8483		Mean dependent variable			2.0651
Adjusted R-squared	0.8302		Std. dependent variable			2.2317
S.E. of regression	0.9195		Akaike info criterion			2.7786
Sum squared resid	71.0276		Schwarz criterion			3.0744
Log likelihood	-120.9858		F-statistic			46.9675
Durbin-Watson stat	1.6207		Prob(F-statistic)			0.0000

Full Sample Period (Jan 1999 - December 2009)

Included observations: 119 after adjustments

Variable	Coefficient	Std. X	Coefficient*	Std. Error	t-Statistic	Prob.
C	-3.70	0.00	0.00	7.58	-0.49	0.6266
DI_EX	19.67	0.03	0.09	12.29	1.60	0.1127
A_7_10	5.16	1.28	1.19	1.60	3.23	0.0017
M1 (Δ3)	0.13	1.54	0.04	0.14	0.93	0.3535
AA_1_3	1.37	0.70	0.17	1.67	0.82	0.4133
OIL (Δ12)	-0.02	36.04	-0.16	0.01	-1.90	0.0601
LTN	-1.32	0.61	-0.14	0.54	-2.44	0.0166
CO_IN	-0.09	9.95	-0.16	0.06	-1.43	0.1555
AAA_3_5	10.99	0.39	0.76	4.08	2.69	0.0084
AAA_7_10	6.33	0.38	0.43	3.75	1.69	0.0944
FEER (Δ12)	-0.20	5.80	-0.21	0.07	-2.77	0.0067
RV_STN	0.03	5.38	0.03	0.03	0.86	0.3901
AA_10_30	1.51	0.55	0.15	1.79	0.84	0.4033
AA_3_5	-6.48	0.66	-0.77	3.90	-1.66	0.1002
OIL (Δ3)	-0.01	18.76	-0.02	0.01	-0.52	0.6066
M2 (Δ12)	0.07	2.00	0.02	0.20	0.32	0.7461
YIELDC	-0.81	0.95	-0.14	0.57	-1.41	0.1605
A_10_30	3.02	0.59	0.32	1.45	2.08	0.0399
A_3_5	-2.77	1.09	-0.54	1.87	-1.48	0.1412
AA_7_10	-20.09	0.69	-2.50	4.39	-4.58	0.0000
RV_STOX50	0.00	17.31	0.01	0.02	0.23	0.8190
R-squared	0.9370		Mean dependent variable			0.0394
Adjusted R-squared	0.9241		Std. dependent variable			5.5497
S.E. of regression	1.5290		Akaike info criterion			3.8459
Sum squared resid	229.1189		Schwarz criterion			4.3364
Log likelihood	-207.8332		F-statistic			72.8239
Durbin-Watson stat	1.2454		Prob(F-statistic)			0.0000

Note 1: *Std. X* is the standard deviation of explanatory variables for the relevant sample period.

Note 2: *Coefficient* is the* normalized coefficient (Coefficient* = Coefficient .* Std.X ./ Std. dependent variable)

Note 3: In the *Coefficient** column -- Orange, dark grey and light grey indicate the 1st three ranks based on the absolute value of standardized coefficients.

Note 4: In the *Prob.* column -- Orange shaded cells - significant at 1% level, dark grey: 5%, light grey: 10%. Standard errors are heteroskedasticity robust (Newey-West).

5 Out-of-sample analysis

As concerns point, directional, and density forecast accuracy, there is a summary table, Table 4 below, that again reduces the full rankings across all models and horizons down to the top-5. The RMSE, DC, and CRPS measures are reported in Tables 9-11 (see Annex) and the corresponding rankings follow in Tables 13-15. Unlike the in-sample estimation results that were presented for two sub-samples (pre-crisis and full sample), there are now three test periods for which simulated out-of-sample forecasts are evaluated: a pre-crisis (Jan 2004 - Dec 2007), crisis (Jan 2008 - Dec 2009), and a full test period (Jan 2004 - Dec 2009).

5.1 Point and directional forecast accuracy

Rankings based on RMSE measures referring to the *pre-crisis* period suggest the following.

- Stock price variables ($\Delta 3$ and $\Delta 12$) occupy the first ranks at short horizons ($H = 1/H = 6$).
- Indicators that rank third to fifth for $H = 1$ include the realized volatility in stock markets and AAA corporate bond spreads (5-10y and 7-10y).
- At the 6-month horizon, the oil price variable ($\Delta 12$) enters the top-5 (it attains rank four).
- At the 12- and 18-month horizon, BBB spreads with various maturities enter the top-5. For either horizon, money growth variables rank fifth (M2 and M1).
- Recursively re-built models from LAR perform well at the 18-month horizon (rank fourth).

Point forecast performance measures for the *full test period* suggest:

- Both at the shortest and the longest horizon ($H = 1$ and $H = 18$), the LAR models perform best in terms of RMSE. The RMSE ratios (see Table

Table 4: Summary out-of-sample analysis, RMSE / DC / CRPS (top-5 ranks)

	Pre-Crisis Period (Jan 2004 - December 2007)											
Eval. Measure	RMSE				DC				CRPS			
Rank / Horizon	1	6	12	18	1	6	12	18	1	6	12	18
1	STOX (Δ3)	STOX (Δ12)	M2 (Δ12)	BBB_1_3	STOX (Δ12)	-	-	-	STOX (Δ12)	LTN	LTN	LTN
2	STOX (Δ12)	STOX (Δ3)	BBB_3_5	BBB_5_10	-	-	-	-	STOX (Δ3)	STOX (Δ12)	M2 (Δ12)	BBB_3_5
3	RV_STOX50	A_1_3	A_1_3	BBB_3_5	-	-	-	-	RV_STOX50	BBB_3_5	M1 (Δ12)	M1 (Δ12)
4	AAA_5_10	OIL (Δ12)	BBB_1_3	LAR	-	-	-	-	M1 (Δ12)	A_7_10	BBB_3_5	BBB_1_3
5	AAA_7_10	BBB_1_3	M2 (Δ12)	M1 (Δ12)	-	-	-	-	OIL (Δ12)	BBB_1_3	BBB_1_3	LAR
	Crisis Period (Jan 2008 - December 2009)											
Eval. Measure	RMSE				DC				CRPS			
Rank / Horizon	1	6	12	18	1	6	12	18	1	6	12	18
1	LAR	M1 (Δ12)	AA_7_10	A_7_10	LAR / RWD	A_5_10	A_7_10	LAR	LAR	M1 (Δ12)	A_7_10	A_7_10
2	RWD	YIELDC	AA_5_10	LAR		AA_7_10	AA_1_3 AA_5_10 A_5_10	AA_7_10	RWD	RWD	AA_7_10	AA_7_10
3	AAA_1_3	RWD	A_5_10	A_5_10	AA_1_3	AA_5_10		A_7_10	AAA_1_3	YIELDC	A_5_10	A_5_10
4	AA_3_5	DI_EX	M1 (Δ12)	AA_7_10	M1/M2 (Δ12)	-		DI_EX	RV_STOX50	A_7_10	AA_5_10	AA_5_10
5	A_5_10	STOX (Δ3)	A_7_10	AA_5_10	RV_STOX50	-		AA_5_10	STOX (Δ3)	AA_1_3	AA_1_3	LAR
	Full Period (Jan 2004 - December 2009)											
Eval. Measure	RMSE				DC				CRPS			
Rank / Horizon	1	6	12	18	1	6	12	18	1	6	12	18
1	LAR	M1 (Δ12)	AA_7_10	LAR	LAR	A_5_10	A_7_10	LAR	LAR	M1 (Δ12)	A_7_10	LAR
2	AAA_1_3	YIELDC	AA_5_10	A_7_10	A_1_3	AA_7_10	AA_1_3	AA_7_10	AAA_1_3	A_7_10	A_5_10	A_7_10
3	AA_3_5	DI_EX	A_5_10	A_5_10	STOX (Δ12)	AA_5_10	AA_5_10	A_7_10	RV_STOX50	LAR	AA_7_10	A_5_10
4	A_5_10	STOX (Δ3)	A_7_10	AA_7_10	RV_STOX50	BBB_5_10	A_5_10	-	STOX (Δ3)	RWD	AA_5_10	AA_7_10
5	AAA_5_10	RWD	AA_1_3	AA_5_10	STOX (Δ3)	-	AA_7_10	-	M1 (Δ12)	RV_STOX50	M1 (Δ12)	M1 (Δ12)

Note: If more than one indicator variable attain a certain rank, then the group of variables is reported in a merged cell. DC cells are empty if more than two variables attain the same rank. Cells holding corporate bond spread variables are shaded in gray; the LAR model in orange.

3) suggest that LAR forecasts have been about 27% more precise than the RWD forecasts for $H = 1$, and about 29% better at the $H = 18$ month horizon.

- The second best model at $H = 1$ is a bivariate one that contains the AAA spread (1-3y).
- When increasing the horizon, the M1 (Δ12) variable starts ranking high (e.g. second and first for $H = 3$ and $H = 6$).
- Second and third ranks at horizons at and below 6 months are occupied by stock prices (Δ3), dispersion in expectations, and the yield curve variable. The latter ranks second at the 6 month horizon.
- At horizons beyond and including 1 year, only corporate spreads appear to be able to outperform the RWD (besides the LAR that ranks first at $H = 18$): the A spread (7-10y) and the A spread (5-10y) rank second and third.

Differences in directional forecast performance for the pre-crisis period can be identified only for rather short horizons; they are less pronounced at horizons beyond 1 year since almost all models under consideration are able to predict the direction of change at longer horizons (pre-crisis) correctly. At the shortest horizon ($H = 1$), the model including stock price changes (Δ12) predicts 75%

of the directions of change in level output correctly. Considering then the *full sample* test period, DC results suggest the following:

- At the shortest horizon ($H = 1$), the LAR models perform best (DC=75%), being followed by the model including the A spread (1-3y), stock prices ($\Delta 12$), and volatility in equity markets, with respective DCs equaling about 71%.
- At the 6-, 12-, and 18-month horizon, the top-5 ranks are occupied solely by the LAR and corporate bond spread models. Dominant appears the bond quality AA with maturities between 5-10y and 7-10y. The LAR model's DC at the 18-month horizon equals 88%, that of the model including the AA (7-10y) spread about 86%. For comparison, the univariate model was able to foresee 74% of the directions of change correctly, the RWD about 46%.

5.2 Density forecast accuracy

Density forecast evaluation results, again for the pre-crisis and full-sample test period are presented along with the point forecast evaluation measures in the reduced summary Table 4; the CRPS are reported in Table 12 and corresponding full rankings in Tables 13-15.

A first glance at the tables already suggests that some indicator variables' ability to generate precise point as opposed to density forecasts diverges to some extent. Considering first the *pre-crisis* test period:

- Stock price changes help render predictive densities at the 1-month horizon more precise; they rank first and second. Other variables ranking high at the shortest horizon are the realized volatility in stock markets, growth in M1 ($\Delta 12$) and the oil price variable ($\Delta 12$). These results suggest some correspondence between the variables' point and density forecast ability at the shortest horizon.
- At the 6-, 12-, and 18-month horizon, the long term interest rate ranks

first. Other models appearing among the top-5 ranks for horizons beyond 6 months are stock price changes ($\Delta 12$), growth in M1 and M2 (both $\Delta 12$), BBB spreads (1-3y and 3-5y), and the LAR model at the 18-month horizon (ranks fifth).

- Spreads from BBB corporate bond yields appear dominant; suggesting that BBB spreads are able to improve both point and density forecast accuracy at longer horizons.

Full-sample test results suggest:

- LAR models rank first both at the $H = 1$ and the $H = 18$ month horizon, and third at the 6-month horizon.
- At the shortest horizon, the AAA spread (1-3y) ranks second, followed by the volatility in stock markets, stock prices ($\Delta 3$) and M1 growth.
- For horizons equal and beyond 6 months, A and AA corporate spreads dominate the top-5 ranks (with maturities of 5-10y and 7-10y).

Relative point and density forecast performance measures seem to suggest that notable differences in the models' performance occur rather for the pre-crisis test period; in particular, the long term interest rate which ranks between 19 and 28 based on point forecast accuracy measures ($H = 12, 15, 18$), ranks first at these horizons with regard to density forecast accuracy. For the crisis-period, the corporate spreads, primarily those referring to medium risk bonds, clearly dominate the highest ranks across all forecast horizons.

For the sake of illustrating how the resulting density forecasts from some of the models look like, Figures 1,2 and 3 show three density forecast plots: the LAR model's forecast, and two BI model density forecasts including a corporate bond spread (AA, 7-10y) and the dispersion in expectation variable. Forecasts presented in these graphs are the 3-month-ahead predictions over the sub-period ranging from January 2007 until December 2009.

Density forecasts from the LAR models as well as the AA corporate bond spread model reveal an interesting pattern: The 3-month-ahead predictions produced in September 2008 (for December 2008) and the subsequent periods

Figure 1: Simulated density forecasts 3-month ahead from LAR models

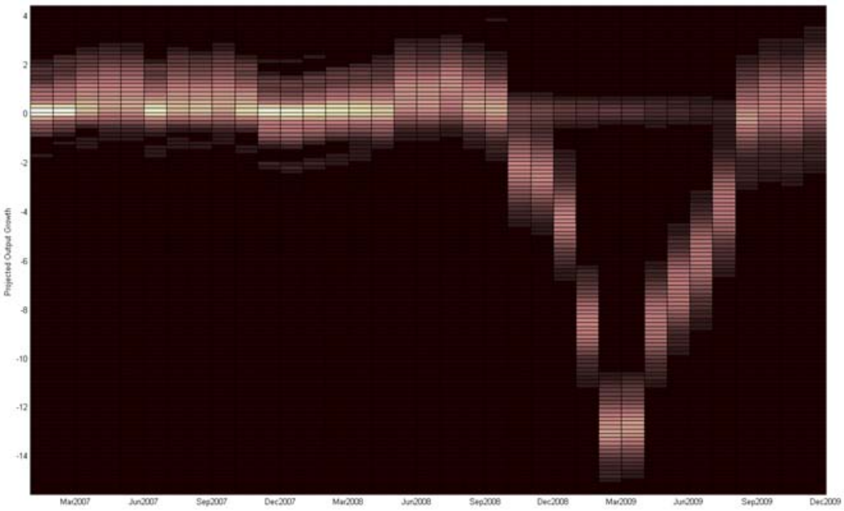


Figure 2: Simulated density forecasts 3-month ahead from model including CBS AA (7-10y)

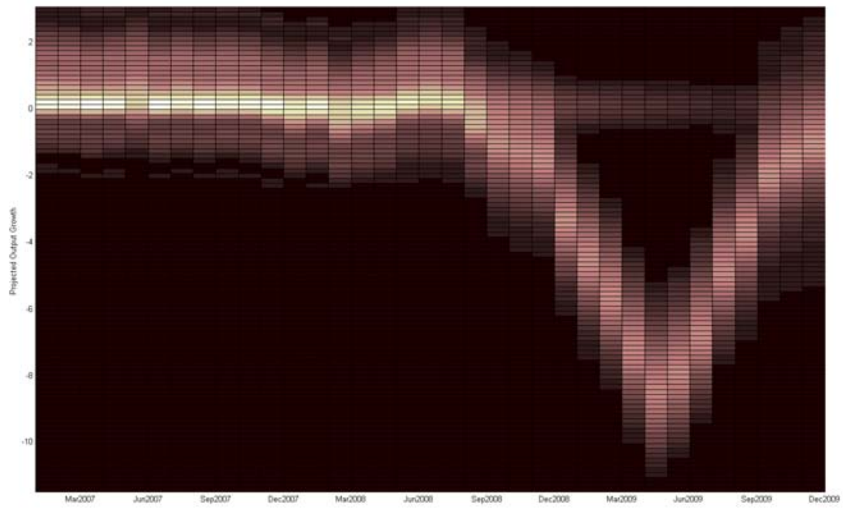
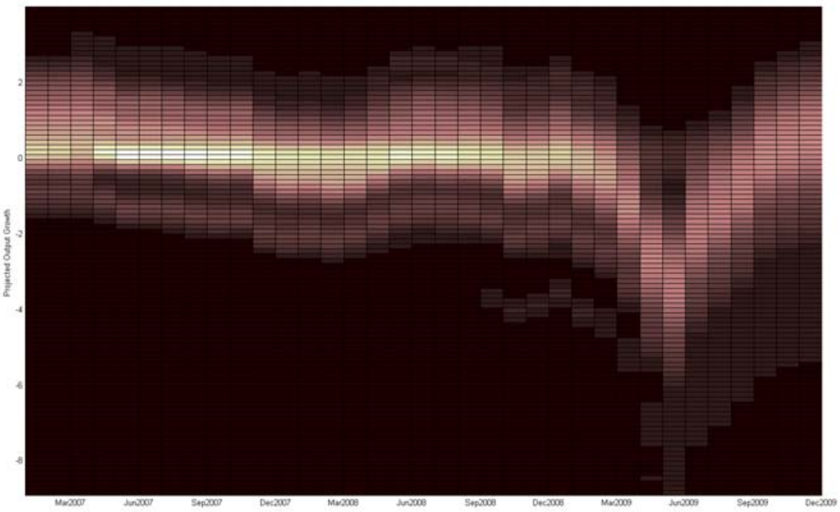


Figure 3: Simulated density forecasts 3-month ahead from model including DI_EX



Note: Figures 1,2, and 3 show out-of-sample predictive densities for euro area output growth. The color is proportional to the surface height, i.e. to the density assigned at a given point in time. The lighter the color the higher is the surface. No distributional assumption is involved; Instead a nonparametric Kernel function is used to estimate the shape of the density forecast at every point in time.

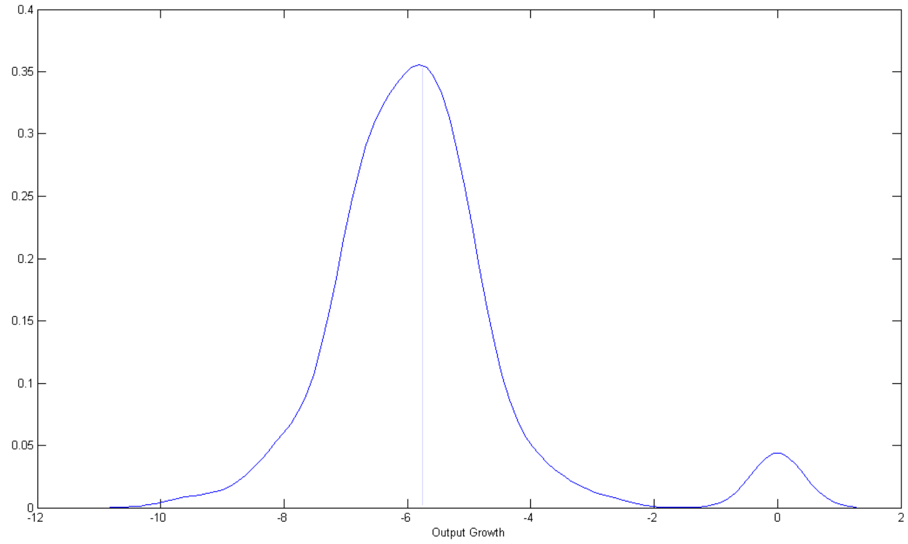
appear to be bi-modal, with one peak occurring round about 0% and a second one gradually shifting down towards -8% to -10% in May/June 2009. Following a period of persistent descent of the model's projection, point forecasts and surrounding densities had a tendency to rise again since May 2009 (forecast origin in February 2009).

Slicing the surface plot at some point during that period and presenting a front view of one density forecast helps further illustrating this bi-modality. Figure 4 shows a view from the front of the LAR model's 3-month-ahead density forecast for June 2009.

5.3 Rank variation over time

Since all direct-step forecast models are estimated and solved recursively, examining the ranks that LAR assigns to all covariates as well as the number of LAR ranks that are included in the model at every point in time can offer additional insight as to how the variables' contribution evolves over time.

Figure 4: Out-of-sample density forecast from LAR model, 3-months ahead for June 2009



Note: The mean prediction corresponding with this density forecast for June 2009 was -5.7% (vertical line). No distributional assumption is involved; Instead, a nonparametric Kernel has been used to smooth the density forecast.

Figures 5 and 6 show how the LAR ranks of selected variables vary over time (for the 1- and 12-month horizon). Note that LAR ranks presented in these graphs, say in the 12-month horizon figure at a given point in time, e.g. in December 2007, are those that have been inferred in this case one year earlier, i.e. were based on information that was available until December 2006.

Table 16 summarizes three additional measures that are based on all models' rank profiles: rank averages, a ranking that sorts covariates according to how significant their LAR ranks have risen through the test period, and a measure of rank variability. The trend ranking is constructed by first regressing all variables' LAR rank series on a constant and time (72 periods) from which heteroskedasticity robust t-statistics for the time variable are recorded; the ranking then follows these t-statistics from most negative to most positive. Clearly, models that trend rather strongly towards higher (or lower) ranks tend to be among those whose ranks vary more over time.

A look at Table 16 and Figures 5 and 6 brings the following additional insight:

Figure 5: Rank variation for selected models, Horizon = 1 month

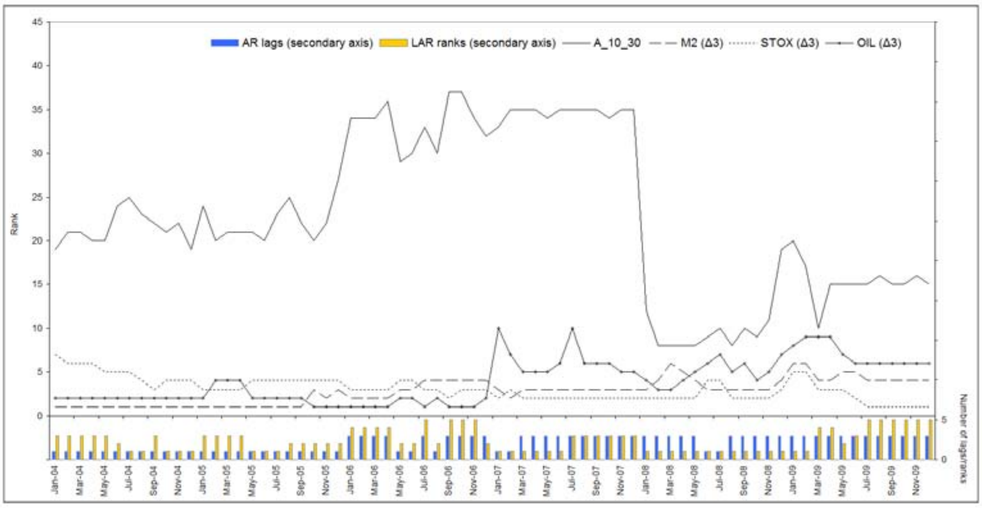
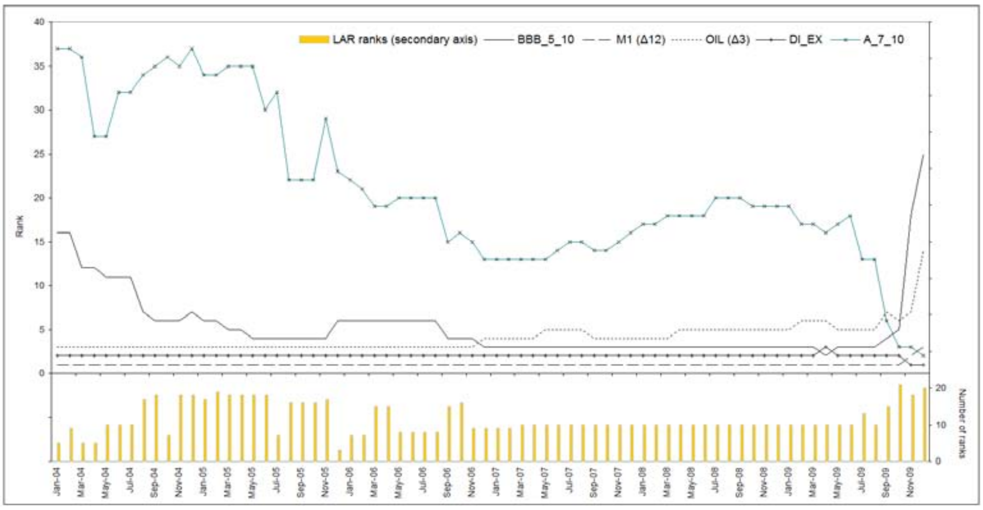


Figure 6: Rank variation for selected models, Horizon = 12 months



- Variables attaining the highest ranks on average after recursive re-estimation through time include oil prices ($\Delta 3$), stock prices ($\Delta 3$), and M2 ($\Delta 3$) for shorter horizons, and the dispersion in expectations variable, M1 ($\Delta 12$), and BBB spreads (5-10y) for longer forecast horizons.

- Indicators whose rank series are the most stable over time are stock prices ($\Delta 3$), M2 ($\Delta 3$), and oil prices ($\Delta 3$) for shorter horizons, and dispersion in expectations and BBB spreads (5-10y) for horizons beyond 6 months. At the 15- and 18-month horizon, also the long term interest rate model exhibits quite stable a rank series.

- Models that experience the strongest trend towards higher ranks include the realized volatility in stock markets at the 1-month horizon, the oil price ($\Delta 12$), M3 ($\Delta 12$) for the 3-month horizon, and numerous corporate bond spreads at and beyond the 6-month horizon, notably the A spread (7-10y) which ranks first with regard to its trending behavior for $H = 12$ and $H = 15$. Despite strong trending towards higher ranks, some of these variables attain rather low ranks on average: e.g. the oil price model ($\Delta 12$) ranks 19th for $H = 3$ and M3 ($\Delta 12$) ranks 26th for $H = 6$.

Table 17 illustrates how often the LAR-selected model variables were in fact included in the model. At the shortest horizon, money growth (M2) was included in 61% of the recursively re-selected models. At the 6-month horizon, M1 growth, dispersion in expectations, and stock returns appear to be most often included. For 12-month forecast models, the AAA corporate bond spread (3-5y) was entering 94% of the models; M1 ($\Delta 12$), oil prices ($\Delta 3$), and the dispersion variable are in fact never excluded from the model at this horizon. The measure of industrial confidence and the BBB corporate bond spread (5-10y) both enter 88% of the models for $H = 12$.

6 Model-implied probabilities of recession

An additional exercise that is meant to shed light on the models' forecast ability is to ask what probability the models would have assigned to some extreme scenario, as actually observed throughout the crisis, from a pre-crisis perspective. To this end, all models are provided with data that were available until August 2007 and then used to produce a sequence of 1- to 18-month ahead forecasts until February 2009, now including all the intermediate horizons. For the purpose of the following exercise, a set of scenario probabilities is extracted from the models' density forecasts by numerically integrating the area below the predictive density at a given forecast horizon (no distributional assumption is involved at this point).

A first set of probabilities refers to the event that growth turns *negative* along the forecast horizon. The upper boundary will therefore be set to 0% growth and the interval will be open to minus infinity. The second set of probabilities is, instead of being tied to a fix threshold value, referring to the actual realization of output growth along the horizon, with the interval still being open to minus infinity. The two sets of model probabilities therefore signal the likelihood of two events: that of a *recession occurring*, which is loosely defined as happening as soon as the over-h-period change in output turns negative, versus the *crisis occurring*, i.e. that output growth evolves as it actually did (or even worse than it did) throughout the 18 month period from September 2007 until February 2009.

Tables 5 and 6 show the resulting set of probabilities. In Table 5, one can see the actual path of output growth reported in the row called *upper bound*. Apart from the short-run 1-month negative change from August to September 2007 (-0.5%), the growth series starts exhibiting a sustained decline only in April 2008, which corresponds to the 8-month ahead change from the perspective of the forecast origin in August 2007. Thereafter, output growth fell steadily until February 2009.

Referring to Table 5, it can be seen that the *recession*, which according to the simple definition started in April 2008, was assigned a 74% probability by the bivariate model containing the dispersion in expectation variable, 67% by the LAR model, and 61% by the bivariate model augmented with the single A corporate bond spread (7-10y). Other indicator variables suggest a much smaller probability of that event: money growth (M2), for instance, still seemed to suggest a very stable growth path with its model implying a recession probability of only 12%. Other model variables that suggest rather low recession probabilities are the foreign exchange volatility, long-term interest rates, stock returns and oil prices. For longer horizons, say 15 months from the origin, i.e. for November 2008 when the percent change over that horizon turned to double-digits, the LAR model would have suggested a 74% probability of negative growth in August 2007, the highest among all models. A closer look at the LAR model's composition at the forecast origin reveals that three variables were contained in the 1-month horizon model: stock prices ($\Delta 3$ and $\Delta 12$) and M2 ($\Delta 3$). The LAR model for $H = 12$ and $H = 18$ turned out to hold the same set of variables: the M1 ($\Delta 12$), dispersion in expectations and the BBB corporate bond spread (5-10y). At the 1-year horizon (around August and September 2008), the models disagree the most along the forecast path, with the standard deviation of the probability equaling about 16.8 percentage points, whereas at the 1-month horizon, quite naturally, they agree the most (standard deviation close to 6 percentage points).

Referring now to Table 6, it can be seen that probabilities for the event that growth along the horizon was to fall below the observed path are higher in comparison to recession probabilities until mid 2008 for the simple reason that growth in output took a positive course for that time being. From the August 2007 perspective, e.g., the actual change over the coming 5 months until January 2008 was +3.4%; all models agree that the probability of growth settling somewhere below this level at that point in time was close to 100%. Thereafter, in particular in the course of the summer of 2008 when growth turned negative, probabilities start to fall off. From August 2007 until June 2008, output shrunk by -1.8% and again, the LAR was the only model that seemed to suggest a reasonably high probability of 32% from the August 2007 perspective. The bivariate models' average probability for the same period was a mere 6.4%. Beyond the 14-month horizon, i.e. for the time after October 2008, all the models' density forecasts implied a probability of no more than 1%. Output growth at these long horizons fell below -10% and was to reach -15.3% in February 2009. None of the models were able to foresee such adverse path as observed towards the end of 2008.

7 Conclusions

This study has been aimed at analyzing the leading indicator properties of corporate bond spreads, as well as of numerous alternative variables capturing macro and financial conditions, for real activity in the euro area.

With regard to the role of corporate bond spreads, a detailed distinction has been made along three dimensions: the securities' qualitiy, their term to maturitiy, as well as the forecast horizon. Bi- and multivariate regression models were estimated to reveal the importance of all variables in-sample. The Least Angle Regression (LAR) method served to supplement the analysis by producing model rankings which can signal the importance of variables relative to each other. Simulated out-of-sample point and density forecasts from all models, also in conjunction with the LAR technique, were used to reveal the variables' ability to predict changes in real activity out-of-sample.

The empirical results can be summarized as follows: considering very short horizons (1 and 3 months), stock price variation, oil price changes, and BBB corporate bond spreads explain the highest portion of variation in output. For the full sample period including the recent financial crisis, models containing corporate bond spread variables, in particular those with A, AA, and AAA rating, gain in relative forecast power. At horizons beyond and including 1 year, single A and BBB bond spreads appear strong. Alternative leading indicators whose predictive content is comparable to that of spread variables are M1 money growth and a measure of dispersion in consumers' expectations.

Estimation results for selected multivariate models, with their composition being suggested by the LAR algorithm, show that a subset of variables contributes especially well to explaining variation in output: at the 12-month horizon, the dispersion in expectations variable, AA and BBB corporate bond spreads, M2 money growth, and a measure of industrial confidence appear among the most relevant variables. Corporate spreads appear among the variables that cause most significant effects: e.g. a one standard deviation increase in AA spreads (7-10 years until maturity) is associated with a fall in output by -2.5 standard deviations a year ahead.

As regards the out-of-sample forecast simulation, point, directional, and density forecast evaluation results conform to the in-sample analysis in that corporate bond spreads appear as valuable leading indicators, in particular at somewhat longer horizons beyond 1 year. Medium risk bond spreads with terms to maturity of up to 10 years improve relative forecast performance the most. The AA spread reduces point forecast errors at the 12-month horizon by 25%-30% relative to the benchmark; other models do on average perform as well or somewhat worse than the benchmark. At the longest horizon (18 months), corporate bond spread models perform best with regard to the direction of change in future output: between 85% and 90% of the signs of change have been predicted correctly over the 6 year test period.

The LAR model technique turns out to be a useful model approach for several reasons. It appears to help identifying the relevant sub-set of variables since the recursively re-built multivariate models render point and density forecasts more precise. At some horizons, the forecasts from LAR models perform best relative to all other models: LAR point predictions are about 30% more precise than the benchmark at the 18-month horizon; the gain in density forecast precision equals about 25%, and close to 90% of the directions of change are predicted correctly. A general conclusion to be drawn from the out-of-sample analysis is that variables can contribute to quite different extends to point as opposed to density forecast accuracy.

Tracking the composition and dimension of the model suggested by LAR over time suggests that the A and AA corporate bond spread variables have shifted towards higher ranks, in particular following the period after the outbreak of the financial crisis in the fall of 2007. BBB spreads' ranks, on the other hand, have not been trending that much, with their rank profile in the sequel being more stable over time. Other variables whose ranks have been trending upwards from the pre- to the post crisis period include, inter alia, M2 growth and the oil price variable.

Models that were fed with corporate bond spread variables are among those that assigned the highest probability to a 'recession' event from a pre-crisis perspective. From an August 2007 standpoint, the probability of moving into recession a year ahead was seen between 60%-70%. The average probability assigned by all other models was a mere 30%-35%. Some indicator variables, in particular also those that generated relatively precise point predictions during the pre-crisis period, suggested a rather stable growth path a year ahead from pre-crisis perspective. Monetary aggregates, e.g. annual growth in M2, suggested a recession probability of below 11%.

By and large, with regard to both in- and out-of-sample estimation and simulation results, there appear variables that could well compete with corporate bond spreads, notably variation in stock prices, money growth, and the level of heterogeneity in beliefs. The latter variable can, in fact, be found among those that suggested the strongest downturn from pre-crisis perspective. Having included the dispersion variable in the model elevated the recession probability for spring 2008 to about 75%. A closer look at the series at the pre-crisis standpoint reveals a level of agreement in expectations about the future course of the economy that was observed to that extent the last time only in May 1993. The strong negative relation between the level of disagreement and future real activity leads the model to predict a strong downturn for the years ahead, at a time when conditions in financial markets were yet relatively calm.

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Annex 1: Data Description and Sources

Variable	Code	Description	Unit	Source
Industrial production	IP_{*s*}	Euro area (changing composition), industrial production index, total industry (excluding construction), seasonally adjusted	Index, log differences over *s* periods in percent	Eurostat
CBS (AAA, 1-3)	AAA_1_3	Merrill Lynch Euro Area Corporate Bond Yield Indices, for various rating classes (AAA, AA, A, BBB) and different maturities: 1-3 years, 3-5 years, 5-7 years, and 10-30 years. Spreads (CBS) are computed from corporate bond yields and benchmark government bond yields at respective maturities. All bond yield series have daily frequency and been converted to monthly by taking period averages. All spreads refer to the euro area (changing composition). All series start in December 1995.	Percentage points	Datastream / Bloomberg
CBS (AAA, 3-5)	AAA_3_5			
CBS (AAA, 5-7)	AAA_5_7			
CBS (AAA, 7-10)	AAA_7_10			
CBS (AAA, 10-30)	AAA_10_30			
CBS (AA, 1-3)	AA_1_3			
CBS (AA, 3-5)	AA_3_5			
CBS (AA, 5-7)	AA_5_7			
CBS (AA, 7-10)	AA_7_10			
CBS (AA, 10-30)	AA_10_30			
CBS (A, 1-3)	A_1_3			
CBS (A, 3-5)	A_3_5			
CBS (A, 5-7)	A_5_7			
CBS (A, 7-10)	A_7_10			
CBS (A, 10-30)	A_10_30			
CBS (BBB, 1-3)	BBB_1_3			
CBS (BBB, 3-5)	BBB_3_5			
CBS (BBB, 5-7)	BBB_5_7			
CBS (BBB, 7-10)	BBB_7_10			
CBS (BBB, 10-30)	BBB_10_30			
Euribor 3-months	EURI	Money market, 3-month Euribor, historical close, daily (converted to monthly by taking period averages)	Percent	ECB
Government bond yield 10 years	GOVB	Euro area (changing composition), 10-year benchmark government bond yield	Percent	Bloomberg
Yield curve	YIELDC	Spread between EURI and GOVB	Percentage points	Own calc.
Industrial confidence indicator	CO_IN	Euro area industrial confidence indicator, seasonally adjusted	Index (b/w +/-100)	EU Commission
Realized volatility 3-month Euribor	RV_STN	Realized 3-month interest rate volatility, euro area (changing composition), converted from daily to monthly by taking period averages	Percent	Own calc.
Realized volatility EUR/USD FX	RV_USDEUR	Realized foreign exchange market volatility EUR-USD	Percent	Own calc.
Realized volatility Eurostoxx50	RV_STOX50	Realized volatility Dow Jones Eurostoxx50 Index, converted from daily to monthly by taking period averages	Percent	Own calc.
Dispersion in expectations	DI_EX	Dispersion in expectations about future price developments, based on answer shares to Q6 in the EC Consumer Survey. For details on how the measure is constructed see Badarinza and Buchmann (2009) and references therein.	Index (b/w 0 and +1)	EU Commission and own calc.
M1 growth	M1 (Δs)	Index of notional stocks (monetary aggregate M1) for the euro area (changing composition), seasonally adjusted	Percentage change over *s* periods	ECB
M2 growth	M2 (Δs)	Index of notional stocks (monetary aggregate M2) for the euro area (changing composition), seasonally adjusted	Percentage change over *s* periods	ECB
M3 growth	M3 (Δs)	Index of notional stocks (monetary aggregate M3) for the euro area (changing composition), seasonally adjusted	Percentage change over *s* periods	ECB
Oil price	OIL (Δs)	Price for brent crude oil, 1-month forward, reference area: world, in euro	Log change over *s* periods	Datastream
Dow Jones Eurostoxx 50	STOX (Δs)	Dow Jones Eurostoxx 50 Index, monthly historical close	Log change over *s* periods	Reuters
Nominal effective EUR exch. Rate	FEER (Δs)	Monthly exchange rate, Euro area 16 vis-à-vis the EER-21 group of trading partners	Log changes over 1 year	ECB

Table 5: Scenario probabilities; Forecast origin August 2007; Probability of ‘negative growth in industrial output’

Scenario Probabilities, Forecast Origin: August 2007																		
Target period	'Sep2007'	'Oct2007'	'Nov2007'	'Dec2007'	'Jan2008'	'Feb2008'	'Mar2008'	'Apr2008'	'May2008'	'Jun2008'	'Jul2008'	'Aug2008'	'Sep2008'	'Oct2008'	'Nov2008'	'Dec2008'	'Jan2009'	'Feb2009'
Forecast horizon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Upper bound	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower bound	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf
RWD	42.49	58.08	46.79	55.00	48.45	66.01	53.90	40.11	58.44	35.84	26.11	27.88	27.57	26.92	27.41	28.57	24.19	23.13
UNI	50.33	27.81	28.34	32.80	37.61	35.54	29.35	27.57	26.80	25.78	24.76	24.92	23.53	23.68	22.72	22.68	22.70	22.08
LAR	65.44	30.53	59.80	61.86	82.65	18.53	48.76	67.38	23.65	87.10	28.12	48.65	88.80	75.52	73.19	67.85	86.57	83.86
AAA_1_3	52.17	25.02	29.35	31.88	40.08	38.69	35.70	33.80	34.54	35.63	34.96	37.16	40.24	39.05	39.19	40.53	40.53	38.18
AA_1_3	56.18	28.39	38.19	38.40	46.92	46.03	44.98	43.99	45.45	47.29	48.62	52.69	56.67	56.16	55.18	55.82	53.85	52.69
A_1_3	53.00	37.15	41.59	40.63	43.65	41.65	39.39	37.51	38.23	37.21	36.71	36.20	36.06	33.98	32.86	32.31	30.48	29.52
BBB_1_3	43.87	25.21	26.78	28.91	31.25	27.93	24.64	24.02	22.58	21.78	21.48	20.75	20.32	20.47	19.42	19.34	18.50	18.20
AAA_3_5	50.09	26.10	26.75	29.44	34.77	32.71	27.21	24.97	24.88	24.30	23.88	23.96	23.20	23.35	23.07	23.25	23.25	22.54
AA_3_5	53.37	27.17	30.14	31.76	34.95	32.23	30.62	27.51	28.56	29.87	27.76	28.14	29.05	27.46	28.56	30.47	31.15	32.14
A_3_5	52.03	32.38	37.87	38.14	39.67	38.23	35.04	33.92	34.37	33.23	32.42	31.65	31.54	30.51	29.82	29.17	28.87	26.76
BBB_3_5	45.29	26.24	26.31	29.28	31.18	27.48	24.07	23.08	21.69	20.64	19.29	19.17	18.07	17.91	16.67	16.83	15.49	14.92
AAA_5_10	53.16	33.10	38.23	40.62	48.28	49.46	41.07	39.56	40.28	41.34	41.22	41.34	43.55	42.32	42.64	44.32	41.41	37.60
AA_5_10	56.85	38.63	47.21	46.90	58.21	58.92	49.55	48.65	50.02	52.81	52.37	54.25	56.17	55.26	56.95	57.67	56.13	56.07
A_5_10	58.72	45.62	52.34	50.32	61.86	60.67	52.74	52.67	52.04	54.90	54.06	54.12	54.65	54.52	55.70	55.92	54.98	55.59
BBB_5_10	51.56	34.80	38.40	38.39	40.85	40.24	34.89	32.41	33.28	31.13	31.41	31.69	31.40	30.95	30.68	30.35	29.69	27.76
AAA_7_10	52.04	28.91	32.34	36.49	42.74	43.20	35.39	34.39	34.44	34.56	33.79	33.22	35.06	33.99	34.51	35.46	32.98	30.76
AA_7_10	58.80	41.91	51.99	50.24	62.39	62.14	53.95	53.34	53.22	56.40	56.72	57.77	59.55	60.17	61.02	62.16	61.29	61.78
A_7_10	62.53	51.26	58.89	56.16	70.33	68.06	60.91	61.25	59.70	61.91	61.62	61.79	63.33	61.85	62.57	62.88	62.27	61.88
BBB_7_10	51.10	32.50	36.71	37.59	38.07	37.01	32.61	31.04	30.56	28.53	28.85	28.77	28.48	28.12	26.78	27.11	25.06	23.53
AAA_10_30	49.17	25.43	25.25	28.78	35.35	32.96	26.98	25.27	25.49	25.39	24.06	24.18	24.07	24.18	23.35	23.57	23.44	22.72
AA_10_30	47.52	24.69	25.02	27.88	35.30	33.02	26.43	24.36	24.33	24.24	24.02	23.88	23.60	24.76	24.29	24.53	25.09	25.13
A_10_30	48.96	25.66	25.42	27.69	34.43	31.32	26.23	24.53	25.36	25.52	24.80	24.71	24.27	24.88	23.60	23.87	23.64	23.28
M1 (Δ3)	48.86	26.79	29.91	33.90	40.05	38.79	30.94	31.15	31.06	31.18	30.41	29.55	29.68	28.82	27.05	28.45	28.03	27.10
M1 (Δ12)	54.83	34.09	41.12	45.16	51.93	50.68	47.37	48.02	48.97	47.83	48.10	51.23	50.83	50.00	49.06	45.18	42.65	39.15
M2 (Δ3)	61.12	30.67	31.13	34.84	39.10	35.98	28.14	25.62	23.26	20.94	20.80	19.72	18.97	18.50	17.17	17.17	16.55	16.84
M2 (Δ12)	47.73	24.33	22.96	23.12	22.51	19.48	13.30	11.74	11.30	10.35	10.31	10.24	10.06	10.08	10.36	10.35	10.57	11.17
M3 (Δ3)	59.36	33.74	35.46	38.97	46.20	45.05	35.34	34.70	32.30	30.21	27.92	27.85	27.08	26.17	24.87	24.65	24.60	24.34
M3 (Δ12)	56.84	34.67	38.94	40.73	43.21	41.00	33.41	31.43	30.53	28.78	29.06	31.95	33.79	33.82	34.94	35.61	38.12	39.50
OIL (Δ3)	50.16	27.55	29.12	32.08	36.78	34.20	28.48	27.92	27.39	26.70	25.47	24.81	23.74	23.32	22.95	22.86	22.21	21.82
OIL (Δ12)	55.79	27.65	30.05	33.33	35.77	31.94	28.33	27.18	26.86	25.94	24.50	24.36	23.20	23.21	23.10	22.51	22.70	22.05
STOX (Δ3)	56.22	33.38	39.90	36.66	39.79	36.95	31.85	31.07	29.38	28.50	27.32	28.57	27.67	27.22	25.62	25.13	25.05	23.51
STOX (Δ12)	44.59	25.06	25.53	27.78	25.30	23.02	24.35	24.81	24.46	23.57	23.47	22.97	22.03	21.98	20.90	21.05	20.63	20.03
FEER (Δ12)	52.57	30.94	32.76	35.21	38.15	35.33	31.43	29.58	28.67	27.79	25.47	25.09	23.44	23.26	22.24	21.12	20.64	19.79
RV_USDEUR	47.46	25.33	25.35	25.14	27.63	26.24	21.36	20.41	18.26	17.66	15.74	14.66	13.69	13.16	13.04	12.73	12.14	12.31
RV_STN	50.15	27.67	28.40	32.13	37.55	35.80	29.23	27.73	26.75	26.38	25.09	24.91	23.85	23.92	22.50	22.38	22.31	21.83
RV_STOX50	52.55	29.23	32.16	32.09	35.48	32.35	29.22	27.86	26.62	24.82	24.64	25.03	23.68	23.96	23.43	23.08	22.95	22.04
DI_EX	67.97	52.04	64.53	65.59	76.58	78.02	75.17	73.62	68.69	67.54	66.48	66.53	66.94	66.61	66.40	66.82	64.29	62.59
CO_IN	42.72	26.28	26.26	29.15	48.04	49.92	28.73	27.56	28.18	28.39	28.16	29.64	30.02	29.39	29.28	29.46	28.84	27.74
LTN	50.27	27.01	28.57	32.63	36.48	34.26	26.20	25.13	22.37	21.64	18.96	17.05	16.36	14.82	14.81	14.43	14.73	15.20
YIELDC	58.15	39.94	48.84	48.70	57.27	57.51	46.54	47.21	47.35	45.54	45.25	45.06	44.28	42.03	41.10	39.52	36.94	34.14
BI model MEAN	52.80	31.53	35.13	36.67	42.38	40.77	34.91	33.76	33.28	32.99	32.30	32.56	32.67	32.17	31.78	31.84	31.14	30.33
BI model STD	5.45	7.18	10.14	9.07	11.88	12.83	12.10	12.40	12.30	13.03	13.29	13.85	14.67	14.49	14.88	15.02	14.57	14.40

Table 6: Scenario probabilities; Forecast origin August 2007; Probability of ‘growth below realization’

Scenario Probabilities, Forecast Origin: August 2007																		
Target period	'Sep2007'	'Oct2007'	'Nov2007'	'Dec2007'	'Jan2008'	'Feb2008'	'Mar2008'	'Apr2008'	'May2008'	'Jun2008'	'Jul2008'	'Aug2008'	'Sep2008'	'Oct2008'	'Nov2008'	'Dec2008'	'Jan2009'	'Feb2009'
Forecast horizon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Upper bound	-0.54	0.87	1.52	2.82	3.41	2.66	2.59	-0.65	-1.37	-1.80	-2.23	-4.10	-5.55	-8.16	-11.14	-12.82	-14.51	-15.31
Lower bound	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf	-Inf
RWD	19.98	86.62	90.90	98.31	98.52	97.87	92.58	25.04	30.15	10.56	5.81	3.21	1.47	0.22	0.01	0.00	0.00	0.00
UNI	15.56	74.77	88.39	97.80	99.68	94.38	82.53	11.98	4.37	2.93	1.83	0.12	0.00	0.00	0.00	0.00	0.00	0.00
LAR	27.50	79.00	99.11	99.81	100.00	96.73	99.39	32.75	1.14	31.88	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AAA_1_3	16.48	72.00	89.12	97.69	99.84	95.74	87.66	17.07	7.75	5.88	4.09	0.83	0.08	0.00	0.00	0.00	0.00	0.00
AA_1_3	19.16	75.82	93.52	98.83	100.00	97.69	95.46	27.16	16.54	13.67	10.48	2.86	0.79	0.01	0.00	0.00	0.00	0.00
A_1_3	16.92	82.06	95.65	99.30	100.00	97.49	95.30	20.46	10.94	8.09	5.64	1.23	0.11	0.00	0.00	0.00	0.00	0.00
BBB_1_3	12.22	70.90	87.88	97.98	99.68	90.43	79.86	12.77	5.13	3.18	1.88	0.18	0.01	0.00	0.00	0.00	0.00	0.00
AAA_3_5	15.24	73.54	87.32	97.15	99.39	92.69	80.42	11.09	4.29	2.81	1.81	0.11	0.00	0.00	0.00	0.00	0.00	0.00
AA_3_5	17.00	74.45	89.42	97.54	99.36	92.60	83.63	11.95	4.85	3.73	2.36	0.24	0.00	0.00	0.00	0.00	0.00	0.00
A_3_5	16.27	78.87	92.92	98.83	99.88	95.96	89.77	17.27	6.71	4.09	2.08	0.19	0.00	0.00	0.00	0.00	0.00	0.00
BBB_3_5	12.90	71.78	86.99	97.43	99.53	90.61	80.32	11.74	4.25	2.32	1.11	0.02	0.00	0.00	0.00	0.00	0.00	0.00
AAA_5_10	16.56	78.36	93.23	98.82	100.00	98.04	91.73	22.54	10.93	7.22	3.93	0.07	0.00	0.00	0.00	0.00	0.00	0.00
AA_5_10	20.13	82.46	95.43	99.34	100.00	99.00	95.93	29.37	18.68	15.24	10.75	1.09	0.03	0.00	0.00	0.00	0.00	0.00
A_5_10	21.66	86.62	96.66	99.55	100.00	99.50	97.96	30.70	20.58	16.20	11.62	1.01	0.05	0.00	0.00	0.00	0.00	0.00
BBB_5_10	16.54	79.84	94.83	99.07	99.98	97.85	92.67	17.26	7.66	5.31	2.77	0.08	0.00	0.00	0.00	0.00	0.00	0.00
AAA_7_10	16.04	76.35	90.66	98.29	99.95	96.48	87.77	17.25	6.72	3.74	2.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00
AA_7_10	21.98	84.14	96.18	99.54	100.00	99.25	97.32	34.05	21.99	19.38	13.73	1.59	0.06	0.00	0.00	0.00	0.00	0.00
A_7_10	25.70	89.15	97.54	99.84	100.00	99.82	99.13	40.07	27.63	23.56	17.95	2.25	0.17	0.00	0.00	0.00	0.00	0.00
BBB_7_10	15.78	78.28	93.62	98.93	99.95	96.35	90.60	14.97	6.59	3.94	2.13	0.02	0.00	0.00	0.00	0.00	0.00	0.00
AAA_10_30	14.73	72.37	86.61	97.01	99.48	93.31	80.00	10.73	4.16	2.99	1.84	0.13	0.00	0.00	0.00	0.00	0.00	0.00
AA_10_30	14.32	70.44	85.34	96.76	99.55	93.17	79.05	10.76	4.45	2.96	1.92	0.13	0.00	0.00	0.00	0.00	0.00	0.00
A_10_30	14.97	72.05	85.54	96.76	99.41	92.60	79.17	11.03	4.39	3.08	1.83	0.12	0.00	0.00	0.00	0.00	0.00	0.00
M1 (Δ3)	15.06	74.49	89.74	98.04	99.79	95.72	85.12	13.87	6.09	4.23	3.24	0.27	0.00	0.00	0.00	0.00	0.00	0.00
M1 (Δ12)	18.59	80.69	95.86	98.83	99.96	98.68	97.21	26.37	10.82	6.32	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M2 (Δ3)	23.30	78.17	90.27	98.32	99.71	94.54	81.59	11.27	4.27	2.93	2.26	0.12	0.00	0.00	0.00	0.00	0.00	0.00
M2 (Δ12)	13.98	69.92	80.99	91.97	95.69	80.09	56.31	5.10	1.28	0.58	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M3 (Δ3)	21.64	79.89	92.37	98.66	99.99	98.10	86.77	17.67	6.30	3.15	1.68	0.34	0.00	0.00	0.00	0.00	0.00	0.00
M3 (Δ12)	20.08	80.52	94.29	99.13	99.94	96.82	85.76	15.37	5.81	3.64	2.57	0.65	0.04	0.00	0.00	0.00	0.00	0.00
OIL (Δ3)	16.12	74.28	90.28	97.33	99.53	93.94	82.49	13.63	5.44	2.28	1.29	0.05	0.00	0.00	0.00	0.00	0.00	0.00
OIL (Δ12)	19.71	75.76	90.68	98.23	99.49	92.95	85.03	12.36	4.66	3.18	2.11	0.18	0.00	0.00	0.00	0.00	0.00	0.00
STOX (Δ3)	19.69	80.80	96.69	99.61	99.80	96.52	90.28	14.85	5.42	3.65	1.96	0.07	0.00	0.00	0.00	0.00	0.00	0.00
STOX (Δ12)	11.32	68.64	88.13	98.10	98.68	83.60	80.58	13.16	5.73	3.30	2.22	0.16	0.00	0.00	0.00	0.00	0.00	0.00
FEER (Δ12)	15.61	77.76	92.38	98.97	99.70	94.47	85.66	14.42	5.91	3.79	2.16	0.15	0.00	0.00	0.00	0.00	0.00	0.00
RV_USDEUR	13.94	71.24	84.42	95.49	98.74	88.63	71.88	10.01	4.14	2.24	0.93	0.02	0.00	0.00	0.00	0.00	0.00	0.00
RV_STN	15.37	74.88	88.54	97.83	99.68	94.44	81.83	11.77	4.40	3.08	1.84	0.11	0.00	0.00	0.00	0.00	0.00	0.00
RV_STOX50	17.00	76.18	90.83	98.31	99.77	94.40	85.37	12.52	4.58	3.14	2.11	0.15	0.00	0.00	0.00	0.00	0.00	0.00
DI_EX	27.81	91.78	98.54	100.00	100.00	100.00	100.00	55.16	32.74	26.49	20.66	5.49	0.59	0.00	0.00	0.00	0.00	0.00
CO_IN	12.07	73.13	85.23	97.08	99.97	98.28	81.86	11.97	4.95	3.32	2.02	0.10	0.00	0.00	0.00	0.00	0.00	0.00
LTN	15.53	74.12	88.93	97.54	99.76	94.48	83.57	10.48	3.24	1.73	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YIELDC	21.25	83.24	96.21	99.58	100.00	99.04	94.82	30.65	16.02	11.10	6.57	0.31	0.00	0.00	0.00	0.00	0.00	0.00
BI model MEAN	17.37	77.16	91.16	98.15	99.63	94.95	86.48	18.08	8.81	6.36	4.24	0.55	0.05	0.00	0.00	0.00	0.00	0.00
BI model STD	3.74	5.44	4.27	1.46	0.74	4.27	8.61	10.04	7.21	6.26	4.85	1.06	0.16	0.00	0.00	0.00	0.00	0.00

Table 7: In-sample analysis – Ranks from BI models and LAR – Pre-Crisis Period

Adj. R^2 BI-MODELS						
Horizon	H=1	H=3	H=6	H=12	H=15	H=18
Effe. smpl length	106	104	101	95	92	89
AR lags	3	0	1	0	0	0
AAA_1_3	0.19	-0.01	0.06	0.05	0.11	0.17
AA_1_3	0.20	0.00	0.07	0.09	0.16	0.19
A_1_3	0.22	0.07	0.14	0.18	0.20	0.22
BBB_1_3	0.24	0.10	0.17	0.19	0.20	0.21
AAA_3_5	0.19	0.00	0.07	0.00	-0.01	-0.01
AA_3_5	0.20	-0.01	0.06	-0.01	-0.01	-0.01
A_3_5	0.22	0.05	0.11	0.11	0.12	0.16
BBB_3_5	0.21	0.08	0.19	0.22	0.24	0.29
AAA_5_10	0.20	0.02	0.13	0.17	0.23	0.25
AA_5_10	0.20	0.02	0.13	0.15	0.21	0.24
A_5_10	0.21	0.06	0.19	0.24	0.29	0.34
BBB_5_10	0.22	0.12	0.24	0.28	0.33	0.38
AAA_7_10	0.20	0.00	0.09	0.07	0.10	0.14
AA_7_10	0.20	0.03	0.13	0.13	0.17	0.21
A_7_10	0.21	0.06	0.18	0.20	0.24	0.27
BBB_7_10	0.23	0.13	0.25	0.18	0.20	0.22
AAA_10_30	0.19	0.01	0.06	-0.01	-0.01	-0.01
AA_10_30	0.20	0.01	0.06	-0.01	-0.01	0.01
A_10_30	0.20	0.02	0.06	-0.01	-0.01	0.01
M1 (Δ3)	0.20	-0.01	0.07	0.09	0.11	0.11
M1 (Δ12)	0.22	0.12	0.28	0.50	0.54	0.43
M2 (Δ3)	0.24	0.00	0.06	0.01	0.01	0.00
M2 (Δ12)	0.19	0.02	0.21	0.20	0.12	0.02
M3 (Δ3)	0.23	0.04	0.09	0.01	0.03	0.06
M3 (Δ12)	0.20	0.01	0.05	0.02	0.12	0.24
OIL (Δ3)	0.23	0.08	0.12	0.09	0.05	0.01
OIL (Δ12)	0.24	0.09	0.08	0.02	-0.01	0.02
STOX (Δ3)	0.26	0.26	0.25	0.14	0.12	0.08
STOX (Δ12)	0.28	0.20	0.22	0.10	0.09	0.10
FEER (Δ12)	0.23	0.06	0.06	-0.01	0.00	0.00
RV_USDEUR	0.20	0.01	0.16	0.12	0.15	0.15
RV_STN	0.19	-0.01	0.06	-0.01	-0.01	-0.01
RV_STOX50	0.24	0.09	0.11	0.05	0.01	0.00
DI_EX	0.22	0.12	0.31	0.32	0.36	0.47
CO_IN	0.20	0.01	0.07	0.02	0.03	0.01
LTN	0.19	0.01	0.15	0.23	0.26	0.21
YIELDC	0.20	0.03	0.10	0.06	0.06	0.06

BI-MODEL RANKING						
Horizon	H=1	H=3	H=6	H=12	H=15	H=18
Effe. smpl length	106	104	101	95	92	89
AR lags	3	0	1	0	0	0
AAA_1_3	36	37	34	25	21	16
AA_1_3	30	33	27	19	14	15
A_1_3	11	12	14	11	11	10
BBB_1_3	5	7	11	9	12	12
AAA_3_5	37	30	28	31	31	37
AA_3_5	27	36	36	36	36	34
A_3_5	13	16	20	17	17	17
BBB_3_5	18	11	9	6	6	5
AAA_5_10	22	22	16	12	8	7
AA_5_10	21	21	17	13	9	8
A_5_10	16	15	8	4	4	4
BBB_5_10	12	6	5	3	3	3
AAA_7_10	24	32	23	22	22	19
AA_7_10	19	19	15	15	13	13
A_7_10	17	14	10	7	7	6
BBB_7_10	8	3	4	10	10	11
AAA_10_30	34	27	31	33	34	36
AA_10_30	31	26	33	35	32	30
A_10_30	26	20	29	37	33	28
M1 (Δ3)	28	34	26	20	20	20
M1 (Δ12)	15	5	2	1	1	2
M2 (Δ3)	6	31	35	29	29	32
M2 (Δ12)	35	23	7	8	16	26
M3 (Δ3)	9	17	22	30	27	23
M3 (Δ12)	25	25	37	27	18	9
OIL (Δ3)	7	10	18	21	25	27
OIL (Δ12)	4	8	24	28	37	25
STOX (Δ3)	2	1	3	14	19	22
STOX (Δ12)	1	2	6	18	23	21
FEER (Δ12)	10	13	30	34	30	31
RV_USDEUR	29	24	12	16	15	18
RV_STN	32	35	32	32	35	35
RV_STOX50	3	9	19	24	28	33
DI_EX	14	4	1	2	2	1
CO_IN	20	29	25	26	26	29
LTN	33	28	13	5	5	14
YIELDC	23	18	21	23	24	24

LAR RANKING						
Horizon	H=1	H=3	H=6	H=12	H=15	H=18
Effe. smpl length	106	104	101	95	92	89
AR lags	3	0	1	0	0	0
LAR ranks	3	4	10	10	20	15
AAA_1_3	32	32	16	33	36	34
AA_1_3	16	22	17	26	10	7
A_1_3	19	36	28	35	6	23
BBB_1_3	18	16	23	21	33	25
AAA_3_5	15	29	25	7	9	13
AA_3_5	23	19	19	27	35	32
A_3_5	29	27	36	18	23	27
BBB_3_5	13	20	30	15	19	17
AAA_5_10	25	35	35	32	28	36
AA_5_10	30	28	29	37	32	33
A_5_10	37	34	37	36	34	6
BBB_5_10	28	26	11	3	2	3
AAA_7_10	7	37	32	25	26	37
AA_7_10	21	10	26	34	27	26
A_7_10	33	23	15	16	15	12
BBB_7_10	20	24	4	19	20	15
AAA_10_30	17	21	27	29	30	30
AA_10_30	10	18	21	10	12	16
A_10_30	35	8	9	13	37	29
M1 (Δ3)	22	30	31	14	22	19
M1 (Δ12)	24	5	2	1	1	2
M2 (Δ3)	3	7	13	31	31	24
M2 (Δ12)	8	9	5	6	8	20
M3 (Δ3)	36	25	6	23	16	28
M3 (Δ12)	31	33	33	24	7	5
OIL (Δ3)	5	4	7	4	5	9
OIL (Δ12)	9	6	10	8	11	21
STOX (Δ3)	2	1	3	28	24	14
STOX (Δ12)	1	2	14	30	21	31
FEER (Δ12)	12	13	20	22	25	35
RV_USDEUR	14	14	24	12	14	10
RV_STN	11	15	12	11	17	11
RV_STOX50	4	12	34	17	18	18
DI_EX	6	3	1	2	3	1
CO_IN	34	31	8	9	13	8
LTN	27	17	18	5	4	4
YIELDC	26	11	22	20	29	22

Note: Left panel: Orange shaded cells when adjusted R-square is larger 50%, dark grey when larger 35%, light-grey when larger 25%. Middle and right panel: Orange, and dark and light-grey shaded cells indicate respective first, second, and third ranks.

Table 8: In-sample analysis – Ranks from BI models and LAR – Full Sample Period

Adj. R^2 BI-MODELS						
Horizon	H=1	H=3	H=6	H=12	H=15	H=18
Effe. smpl length	130	128	125	119	116	113
AR lags	3	1	1	0	0	0
AAA_1_3	0.33	0.50	0.54	0.15	0.08	0.12
AA_1_3	0.27	0.43	0.60	0.34	0.12	0.15
A_1_3	0.28	0.43	0.56	0.23	0.16	0.24
BBB_1_3	0.24	0.34	0.40	0.08	0.13	0.22
AAA_3_5	0.28	0.41	0.45	-0.01	-0.01	0.01
AA_3_5	0.31	0.49	0.60	0.13	0.00	0.04
A_3_5	0.28	0.42	0.56	0.17	0.09	0.22
BBB_3_5	0.26	0.39	0.45	0.09	0.15	0.31
AAA_5_10	0.29	0.46	0.56	0.21	0.21	0.27
AA_5_10	0.29	0.49	0.66	0.35	0.20	0.25
A_5_10	0.31	0.51	0.64	0.40	0.26	0.33
BBB_5_10	0.26	0.40	0.56	0.24	0.24	0.36
AAA_7_10	0.26	0.40	0.54	0.12	0.12	0.19
AA_7_10	0.29	0.47	0.66	0.38	0.19	0.25
A_7_10	0.31	0.49	0.64	0.43	0.22	0.28
BBB_7_10	0.26	0.40	0.56	0.16	0.14	0.22
AAA_10_30	0.28	0.40	0.44	0.01	0.00	0.01
AA_10_30	0.29	0.44	0.55	0.04	0.00	0.02
A_10_30	0.25	0.37	0.49	0.02	0.00	0.03
M1 (Δ3)	0.22	0.33	0.42	0.13	0.09	0.12
M1 (Δ12)	0.26	0.46	0.59	0.41	0.45	0.35
M2 (Δ3)	0.27	0.34	0.36	0.00	0.00	0.03
M2 (Δ12)	0.24	0.35	0.40	0.00	0.05	0.09
M3 (Δ3)	0.25	0.34	0.38	0.06	0.03	0.00
M3 (Δ12)	0.24	0.36	0.42	0.16	0.07	0.04
OIL (Δ3)	0.28	0.36	0.35	0.01	0.02	0.03
OIL (Δ12)	0.22	0.32	0.40	0.00	0.01	-0.01
STOX (Δ3)	0.30	0.49	0.43	0.07	0.09	0.08
STOX (Δ12)	0.25	0.37	0.38	0.04	0.08	0.11
FEER (Δ12)	0.22	0.33	0.36	0.01	-0.01	0.00
RV_USDEUR	0.24	0.33	0.37	-0.01	0.02	0.12
RV_STN	0.22	0.31	0.35	0.00	-0.01	0.02
RV_STOX50	0.30	0.40	0.36	0.00	0.02	0.04
DI_EX	0.23	0.37	0.51	0.45	0.34	0.28
CO_IN	0.22	0.31	0.40	0.05	0.04	0.01
LTN	0.22	0.31	0.36	0.11	0.27	0.31
YIELDC	0.28	0.44	0.53	0.19	0.05	0.02

BI-MODEL RANKING						
Horizon	H=1	H=3	H=6	H=12	H=15	H=18
Effe. smpl length	130	128	125	119	116	113
AR lags	3	1	1	0	0	0
AAA_1_3	1	2	14	15	19	17
AA_1_3	17	13	6	7	14	16
A_1_3	11	12	8	9	10	11
BBB_1_3	27	30	25	21	13	12
AAA_3_5	15	15	20	36	36	33
AA_3_5	3	5	5	16	31	24
A_3_5	14	14	9	12	18	14
BBB_3_5	22	21	19	20	11	4
AAA_5_10	8	8	12	10	7	8
AA_5_10	7	4	1	6	8	10
A_5_10	2	1	3	4	4	3
BBB_5_10	23	17	11	8	5	1
AAA_7_10	20	18	15	18	15	15
AA_7_10	9	7	2	5	9	9
A_7_10	4	3	4	2	6	6
BBB_7_10	21	16	10	14	12	13
AAA_10_30	12	19	21	29	33	32
AA_10_30	10	10	13	25	32	29
A_10_30	24	23	18	27	34	28
M1 (Δ3)	33	31	24	17	17	18
M1 (Δ12)	19	9	7	3	1	2
M2 (Δ3)	18	28	34	34	30	27
M2 (Δ12)	28	27	28	33	22	21
M3 (Δ3)	26	29	29	23	25	36
M3 (Δ12)	30	26	23	13	21	25
OIL (Δ3)	13	25	37	30	28	26
OIL (Δ12)	36	34	27	31	29	37
STOX (Δ3)	5	6	22	22	16	22
STOX (Δ12)	25	22	30	26	20	20
FEER (Δ12)	32	32	32	28	37	35
RV_USDEUR	29	33	31	37	27	19
RV_STN	35	37	36	35	35	30
RV_STOX50	6	20	35	32	26	23
DI_EX	31	24	17	1	2	7
CO_IN	34	35	26	24	24	34
LTN	37	36	33	19	3	5
YIELDC	16	11	16	11	23	31

LAR RANKING						
Horizon	H=1	H=3	H=6	H=12	H=15	H=18
Effe. smpl length	130	128	125	119	116	113
AR lags	3	1	1	0	0	0
LAR ranks	5	4	7	20	22	9
AAA_1_3	5	4	18	28	35	24
AA_1_3	32	23	24	4	8	8
A_1_3	25	34	35	36	11	10
BBB_1_3	11	11	15	29	36	30
AAA_3_5	34	29	16	8	16	36
AA_3_5	19	12	27	13	29	34
A_3_5	30	33	29	18	28	31
BBB_3_5	23	36	33	21	20	14
AAA_5_10	31	27	20	35	33	12
AA_5_10	26	17	2	37	37	35
A_5_10	36	20	34	32	4	5
BBB_5_10	37	26	36	25	5	1
AAA_7_10	29	24	30	9	31	28
AA_7_10	28	35	37	19	17	20
A_7_10	35	37	31	2	12	11
BBB_7_10	13	22	17	26	22	22
AAA_10_30	8	31	14	31	26	26
AA_10_30	22	15	9	12	19	19
A_10_30	15	19	21	17	32	33
M1 (Δ3)	14	16	32	33	14	29
M1 (Δ12)	27	3	1	3	1	2
M2 (Δ3)	4	7	28	23	27	27
M2 (Δ12)	20	28	22	15	24	15
M3 (Δ3)	21	21	13	34	13	25
M3 (Δ12)	12	13	11	24	6	7
OIL (Δ3)	6	9	26	14	21	6
OIL (Δ12)	7	6	5	5	10	16
STOX (Δ3)	1	1	6	30	18	18
STOX (Δ12)	33	18	25	27	30	32
FEER (Δ12)	16	10	7	10	34	37
RV_USDEUR	17	14	10	22	23	23
RV_STN	24	32	19	11	15	17
RV_STOX50	2	8	23	20	25	21
DI_EX	10	5	3	1	2	4
CO_IN	9	30	8	7	7	9
LTN	18	25	12	6	3	3
YIELDC	3	2	4	16	9	13

Note: Left panel: Orange shaded cells when adjusted R-square is larger 50%, dark grey when larger 35%, light-grey when larger 25%. Middle and right panel: Orange, and dark and light-grey shaded cells indicate respective first, second, and third ranks.

Table 9: RMSE and DC, Full sample period (January 2004 – December 2009)

	RMSE					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	1.07	2.00	4.30	6.70	8.23	9.75
UNI	0.90	2.13	4.86	7.26	8.30	9.39
LAR	0.79	2.20	7.11	8.18	6.88	6.91
AAA_1_3	0.81	1.90	4.72	6.28	7.31	8.55
AA_1_3	0.88	2.23	5.66	5.82	6.26	7.84
A_1_3	0.88	2.32	6.43	6.18	6.43	7.96
BBB_1_3	0.91	2.26	5.01	6.65	7.84	8.72
AAA_3_5	0.87	2.18	5.17	7.51	8.34	9.36
AA_3_5	0.84	2.04	5.07	6.76	7.64	8.65
A_3_5	0.88	2.26	5.85	5.94	6.91	8.25
BBB_3_5	0.88	2.12	4.85	6.49	7.68	8.74
AAA_5_10	0.84	1.97	4.78	6.03	7.10	8.41
AA_5_10	0.85	1.99	4.85	5.32	6.16	7.67
A_5_10	0.84	1.99	5.22	5.55	5.76	7.27
BBB_5_10	0.90	2.37	5.96	5.89	6.89	7.93
AAA_7_10	0.88	2.17	5.25	6.39	7.43	8.68
AA_7_10	0.86	2.05	5.05	5.28	5.90	7.41
A_7_10	0.86	2.06	5.49	5.78	5.47	7.11
BBB_7_10	0.91	2.38	5.88	6.11	7.27	8.49
AAA_10_30	0.87	2.14	5.00	7.28	8.25	9.32
AA_10_30	0.86	2.06	5.12	7.16	8.13	9.08
A_10_30	0.90	2.29	5.72	7.20	8.12	9.05
M1 (Δ3)	0.92	2.12	4.71	6.93	7.84	8.82
M1 (Δ12)	0.87	1.87	3.82	5.90	6.82	7.85
M2 (Δ3)	0.90	2.09	4.74	7.42	8.60	9.78
M2 (Δ12)	0.90	2.12	4.92	8.28	9.64	10.51
M3 (Δ3)	0.91	2.10	4.69	7.23	8.22	9.20
M3 (Δ12)	0.91	2.09	4.56	7.11	7.88	8.38
OIL (Δ3)	0.89	2.10	4.80	7.29	8.39	9.53
OIL (Δ12)	0.93	2.16	4.87	7.33	8.36	9.42
STOX (Δ3)	0.85	1.83	4.30	6.86	7.98	9.18
STOX (Δ12)	0.90	2.02	4.36	7.00	8.08	9.02
FEER (Δ12)	0.92	2.12	4.63	7.23	8.41	9.69
RV_USDEUR	0.89	2.13	4.89	7.34	8.66	9.89
RV_STN	0.91	2.14	4.85	7.28	8.33	9.59
RV_STOX50	0.85	1.99	4.66	7.13	8.35	9.60
DI_EX	0.92	2.10	4.27	6.36	6.87	7.67
CO_IN	0.92	2.14	4.77	7.37	8.18	8.96
LTN	0.91	2.13	4.84	7.32	8.45	9.52
YIELDC	0.88	1.98	4.11	6.81	7.86	8.95

	RMSE RATIOS					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD						
UNI	0.84	1.06	1.13	1.08	1.01	0.96
LAR	0.73	1.10	1.65	1.22	0.84	0.71
AAA_1_3	0.76	0.95	1.10	0.94	0.89	0.88
AA_1_3	0.82	1.11	1.31	0.87	0.76	0.80
A_1_3	0.82	1.16	1.49	0.92	0.78	0.82
BBB_1_3	0.85	1.13	1.16	0.99	0.95	0.89
AAA_3_5	0.81	1.09	1.20	1.12	1.01	0.96
AA_3_5	0.78	1.02	1.18	1.01	0.93	0.89
A_3_5	0.82	1.13	1.36	0.89	0.84	0.85
BBB_3_5	0.82	1.06	1.13	0.97	0.93	0.90
AAA_5_10	0.79	0.98	1.11	0.90	0.86	0.86
AA_5_10	0.80	0.99	1.13	0.79	0.75	0.79
A_5_10	0.79	0.99	1.21	0.83	0.70	0.75
BBB_5_10	0.84	1.18	1.39	0.88	0.84	0.81
AAA_7_10	0.82	1.08	1.22	0.95	0.90	0.89
AA_7_10	0.81	1.02	1.17	0.79	0.72	0.76
A_7_10	0.80	1.03	1.28	0.86	0.66	0.73
BBB_7_10	0.85	1.18	1.37	0.91	0.88	0.87
AAA_10_30	0.81	1.07	1.16	1.09	1.00	0.96
AA_10_30	0.81	1.03	1.19	1.07	0.99	0.93
A_10_30	0.84	1.14	1.33	1.07	0.99	0.93
M1 (Δ3)	0.86	1.06	1.09	1.03	0.95	0.91
M1 (Δ12)	0.81	0.93	0.89	0.88	0.83	0.80
M2 (Δ3)	0.84	1.04	1.10	1.11	1.05	1.00
M2 (Δ12)	0.84	1.06	1.14	1.23	1.17	1.08
M3 (Δ3)	0.85	1.05	1.09	1.08	1.00	0.94
M3 (Δ12)	0.85	1.04	1.06	1.06	0.96	0.86
OIL (Δ3)	0.83	1.05	1.12	1.09	1.02	0.98
OIL (Δ12)	0.87	1.08	1.13	1.09	1.02	0.97
STOX (Δ3)	0.79	0.91	1.00	1.02	0.97	0.94
STOX (Δ12)	0.84	1.01	1.01	1.04	0.98	0.93
FEER (Δ12)	0.86	1.06	1.08	1.08	1.02	0.99
RV_USDEUR	0.83	1.06	1.14	1.10	1.05	1.01
RV_STN	0.85	1.07	1.13	1.09	1.01	0.98
RV_STOX50	0.79	0.99	1.08	1.06	1.02	0.98
DI_EX	0.86	1.05	0.99	0.95	0.83	0.79
CO_IN	0.85	1.07	1.11	1.10	0.99	0.92
LTN	0.85	1.06	1.13	1.09	1.03	0.98
YIELDC	0.82	0.99	0.96	1.02	0.96	0.92

	CW					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	-	-	-	-	-	-
UNI	3.52	1.50	0.42	0.31	1.05	3.60
LAR	3.96	1.90	-1.02	1.64	2.81	3.05
AAA_1_3	3.65	2.80	-0.50	1.95	2.52	3.59
AA_1_3	3.47	0.40	-1.02	1.82	2.28	3.03
A_1_3	3.54	0.57	-0.72	1.66	2.49	3.14
BBB_1_3	3.28	0.36	-0.79	0.97	1.70	4.19
AAA_3_5	3.43	1.34	-0.98	-0.09	0.99	3.70
AA_3_5	3.52	1.62	-1.06	0.60	2.11	3.43
A_3_5	3.40	0.39	-0.87	1.91	2.49	3.29
BBB_3_5	3.40	0.90	-0.58	1.38	2.04	3.71
AAA_5_10	3.42	1.89	-0.56	2.63	3.02	3.91
AA_5_10	3.48	1.56	-0.48	2.17	2.49	3.16
A_5_10	3.50	1.25	-0.37	1.94	2.45	2.96
BBB_5_10	3.32	0.19	-0.89	2.03	2.47	3.41
AAA_7_10	3.33	0.80	-1.05	1.86	2.70	3.93
AA_7_10	3.41	1.09	-0.56	2.04	2.40	2.98
A_7_10	3.47	1.02	-0.44	1.85	2.37	2.85
BBB_7_10	3.29	0.17	-0.82	2.05	2.55	3.78
AAA_10_30	3.48	1.56	-0.35	-0.06	1.01	3.50
AA_10_30	3.63	2.13	-1.00	0.08	1.51	4.00
A_10_30	3.36	0.56	-1.38	0.07	1.41	3.90
M1 (Δ3)	3.51	1.54	0.68	1.28	2.09	4.04
M1 (Δ12)	3.60	1.94	1.43	3.11	3.18	4.10
M2 (Δ3)	3.70	1.62	0.56	-0.06	0.38	2.99
M2 (Δ12)	3.59	1.54	0.29	-0.98	-0.98	1.01
M3 (Δ3)	3.65	1.60	0.70	0.41	1.17	3.60
M3 (Δ12)	3.61	1.65	0.80	0.65	1.66	3.30
OIL (Δ3)	3.58	1.66	0.46	0.08	0.87	3.48
OIL (Δ12)	3.46	1.49	0.41	0.13	0.93	3.47
STOX (Δ3)	3.66	2.12	1.00	0.93	1.66	3.82
STOX (Δ12)	3.57	1.68	0.98	0.58	1.18	3.88
FEER (Δ12)	3.50	1.59	0.81	0.39	1.04	3.54
RV_USDEUR	3.48	1.43	0.02	0.00	0.37	2.51
RV_STN	3.51	1.49	0.44	0.27	0.96	3.44
RV_STOX50	3.61	1.76	0.53	0.36	1.07	3.43
DI_EX	3.52	1.64	1.26	1.87	1.87	2.62
CO_IN	3.49	1.49	0.60	0.59	1.28	3.88
LTN	3.50	1.49	0.43	0.67	1.55	4.76
YIELDC	3.74	1.79	1.15	1.52	2.12	3.95

	DC					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	58.33	80.56	70.83	70.83	59.72	45.83
UNI	66.67	76.39	69.44	72.22	72.22	73.61
LAR	75.00	80.56	76.39	73.61	86.11	87.50
AAA_1_3	66.67	80.56	76.39	81.94	80.56	79.17
AA_1_3	66.67	81.94	77.78	93.06	88.89	84.72
A_1_3	70.83	86.11	84.72	87.50	83.33	80.56
BBB_1_3	66.67	81.94	75.00	77.78	70.83	73.61
AAA_3_5	61.11	68.06	68.06	70.83	72.22	73.61
AA_3_5	65.28	79.17	62.50	77.78	75.00	79.17
A_3_5	63.89	84.72	83.33	87.50	83.33	80.56
BBB_3_5	66.67	83.33	77.78	79.17	75.00	75.00
AAA_5_10	66.67	81.94	81.94	86.11	81.94	79.17
AA_5_10	66.67	80.56	86.11	93.06	88.89	84.72
A_5_10	63.89	80.56	87.50	93.06	88.89	84.72
BBB_5_10	68.06	87.50	84.72	88.89	83.33	80.56
AAA_7_10	66.67	80.56	76.39	81.94	77.78	76.39
AA_7_10	68.06	79.17	87.50	93.06	88.89	86.11
A_7_10	63.89	77.78	84.72	94.44	90.28	86.11
BBB_7_10	68.06	87.50	84.72	87.50	81.94	77.78
AAA_10_30	66.67	62.50	61.11	72.22	72.22	73.61
AA_10_30	62.50	75.00	72.22	76.39	72.22	73.61
A_10_30	62.50	65.28	68.06	73.61	72.22	73.61
M1 (Δ3)	65.28	77.78	69.44	72.22	72.22	73.61
M1 (Δ12)	68.06	86.11	84.72	88.89	86.11	83.33
M2 (Δ3)	58.33	79.17	69.44	72.22	72.22	73.61
M2 (Δ12)	66.67	79.17	68.06	72.22	72.22	73.61
M3 (Δ3)	62.50	75.00	69.44	72.22	72.22	73.61
M3 (Δ12)	62.50	79.17	68.06	72.22	72.22	73.61
OIL (Δ3)	66.67	75.00	72.22	73.61	72.22	73.61
OIL (Δ12)	63.89	77.78	69.44	72.22	72.22	73.61
STOX (Δ3)	69.44	86.11	76.39	76.39	72.22	73.61
STOX (Δ12)	70.83	80.56	75.00	66.67	66.67	73.61
FEER (Δ12)	61.11	73.61	66.67	72.22	72.22	73.61
RV_USDEUR	66.67	76.39	73.61	72.22	72.22	73.61
RV_STN	66.67	76.39	66.67	72.22	72.22	73.61
RV_STOX50	70.83	76.39	73.61	73.61	72.22	73.61
DI_EX	58.33	73.61	65.28	73.61	69.44	72.22
CO_IN	68.06	77.78	62.50	72.22	72.22	73.61
LTN	62.50	77.78	69.44	72.22	72.22	73.61
YIELDC	65.28	83.33	75.00	75.00	72.22	73.61

Table 10: RMSE and DC, Pre-crisis period (January 2004 – December 2007)

	RMSE					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	1.07	0.99	1.69	2.36	2.91	3.86
UNI	0.58	0.74	1.25	1.75	2.52	4.82
LAR	0.64	0.84	1.37	2.87	3.36	3.45
AAA_1_3	0.58	0.75	1.25	1.71	2.43	4.62
AA_1_3	0.59	0.75	1.24	1.68	2.33	4.51
A_1_3	0.58	0.72	1.17	1.43	1.82	3.86
BBB_1_3	0.59	0.75	1.19	1.47	1.60	2.80
AAA_3_5	0.60	0.86	1.48	2.12	2.70	5.18
AA_3_5	0.59	0.83	1.52	2.16	2.72	5.06
A_3_5	0.59	0.76	1.22	1.50	2.09	4.29
BBB_3_5	0.58	0.77	1.23	1.42	1.58	3.17
AAA_5_10	0.58	0.73	1.20	1.60	2.34	4.47
AA_5_10	0.58	0.74	1.22	1.58	2.24	4.38
A_5_10	0.59	0.78	1.26	1.61	2.10	4.04
BBB_5_10	0.59	0.82	1.29	1.61	1.76	3.13
AAA_7_10	0.58	0.75	1.24	1.60	2.40	4.71
AA_7_10	0.59	0.74	1.21	1.52	2.20	4.40
A_7_10	0.60	0.79	1.25	1.52	2.10	4.22
BBB_7_10	0.61	0.90	1.51	1.66	2.05	4.07
AAA_10_30	0.60	0.86	1.45	2.29	2.83	5.14
AA_10_30	0.58	0.77	1.33	1.80	2.63	5.04
A_10_30	0.59	0.80	1.36	1.89	2.55	4.78
M1 (Δ3)	0.60	0.76	1.25	1.69	2.47	4.55
M1 (Δ12)	0.58	0.78	1.43	2.20	2.62	3.78
M2 (Δ3)	0.63	0.79	1.28	1.69	2.42	4.76
M2 (Δ12)	0.60	0.73	1.38	1.31	1.94	4.34
M3 (Δ3)	0.62	0.84	1.32	1.98	2.64	4.80
M3 (Δ12)	0.63	0.87	1.39	2.29	2.88	4.40
OIL (Δ3)	0.63	0.84	1.25	1.83	2.43	4.96
OIL (Δ12)	0.59	0.76	1.18	1.67	2.59	4.90
STOX (Δ3)	0.56	0.66	1.16	1.61	2.26	4.58
STOX (Δ12)	0.56	0.72	1.14	1.76	2.32	3.88
FEER (Δ12)	0.59	0.78	1.28	1.75	2.74	5.27
RV_USDEUR	0.59	0.74	1.32	1.59	2.56	4.51
RV_STN	0.58	0.75	1.33	1.91	2.68	5.20
RV_STOX50	0.58	0.73	1.21	1.63	2.73	5.23
DI_EX	0.59	0.76	1.24	2.26	2.90	3.94
CO_IN	0.59	0.76	1.36	1.85	2.40	4.11
LTN	0.60	0.75	1.23	1.68	2.64	4.46
YIELDC	0.63	0.93	1.44	2.30	2.82	4.89

	RMSE RATIOS					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD						
UNI	0.54	0.75	0.74	0.74	0.87	1.25
LAR	0.59	0.85	0.81	1.22	1.16	0.89
AAA_1_3	0.54	0.76	0.74	0.72	0.84	1.20
AA_1_3	0.55	0.76	0.74	0.71	0.80	1.17
A_1_3	0.54	0.73	0.69	0.60	0.63	1.00
BBB_1_3	0.55	0.76	0.71	0.62	0.55	0.73
AAA_3_5	0.56	0.87	0.88	0.90	0.93	1.34
AA_3_5	0.55	0.84	0.90	0.91	0.94	1.31
A_3_5	0.55	0.77	0.72	0.64	0.72	1.11
BBB_3_5	0.54	0.78	0.73	0.60	0.54	0.82
AAA_5_10	0.54	0.74	0.71	0.68	0.81	1.16
AA_5_10	0.54	0.75	0.73	0.67	0.77	1.14
A_5_10	0.55	0.79	0.75	0.68	0.72	1.05
BBB_5_10	0.55	0.83	0.76	0.68	0.61	0.81
AAA_7_10	0.54	0.76	0.73	0.68	0.83	1.22
AA_7_10	0.55	0.75	0.72	0.64	0.76	1.14
A_7_10	0.56	0.80	0.74	0.65	0.72	1.09
BBB_7_10	0.57	0.91	0.90	0.70	0.71	1.06
AAA_10_30	0.56	0.87	0.86	0.97	0.97	1.33
AA_10_30	0.55	0.78	0.79	0.76	0.90	1.30
A_10_30	0.55	0.81	0.81	0.80	0.88	1.24
M1 (Δ3)	0.56	0.77	0.74	0.72	0.85	1.18
M1 (Δ12)	0.54	0.79	0.85	0.93	0.90	0.98
M2 (Δ3)	0.59	0.80	0.76	0.71	0.83	1.23
M2 (Δ12)	0.56	0.74	0.82	0.55	0.67	1.12
M3 (Δ3)	0.58	0.85	0.78	0.84	0.91	1.24
M3 (Δ12)	0.59	0.88	0.82	0.97	0.99	1.14
OIL (Δ3)	0.58	0.85	0.74	0.78	0.84	1.29
OIL (Δ12)	0.55	0.77	0.70	0.71	0.89	1.27
STOX (Δ3)	0.52	0.67	0.69	0.68	0.78	1.19
STOX (Δ12)	0.53	0.73	0.68	0.75	0.80	1.01
FEER (Δ12)	0.55	0.79	0.76	0.74	0.94	1.37
RV_USDEUR	0.55	0.75	0.78	0.67	0.88	1.17
RV_STN	0.54	0.76	0.79	0.81	0.92	1.35
RV_STOX50	0.54	0.74	0.72	0.69	0.94	1.36
DI_EX	0.55	0.77	0.73	0.96	1.00	1.02
CO_IN	0.55	0.76	0.81	0.79	0.83	1.06
LTN	0.56	0.76	0.73	0.71	0.91	1.16
YIELDC	0.58	0.94	0.86	0.98	0.97	1.27

	CW					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD						
UNI	3.57	2.94	3.50	3.11	3.11	2.79
LAR	3.58	2.47	2.85	3.29	4.51	6.41
AAA_1_3	3.55	2.91	3.49	3.16	3.17	2.78
AA_1_3	3.52	2.89	3.56	3.28	3.31	2.79
A_1_3	3.53	3.25	3.96	3.44	3.97	3.14
BBB_1_3	3.58	3.42	3.88	3.37	5.04	3.97
AAA_3_5	3.56	2.60	2.69	2.44	2.81	2.72
AA_3_5	3.52	2.71	2.54	2.26	2.75	2.79
A_3_5	3.52	3.07	3.60	3.36	3.97	3.53
BBB_3_5	3.56	3.30	3.60	3.31	4.69	4.06
AAA_5_10	3.51	2.84	3.28	3.24	3.78	3.27
AA_5_10	3.49	2.77	3.16	3.29	3.91	3.29
A_5_10	3.49	2.65	2.88	3.32	4.25	3.57
BBB_5_10	3.52	2.81	3.10	3.24	4.76	3.92
AAA_7_10	3.53	2.89	3.41	3.23	3.56	3.18
AA_7_10	3.48	2.77	3.20	3.36	3.93	3.36
A_7_10	3.48	2.59	2.95	3.43	4.17	3.44
BBB_7_10	3.52	2.60	2.37	3.21	4.27	3.55
AAA_10_30	3.59	2.84	2.80	1.95	2.27	2.48
AA_10_30	3.59	3.20	3.25	3.06	3.01	2.94
A_10_30	3.59	3.02	3.00	2.86	2.98	2.91
M1 (Δ3)	3.58	2.89	3.65	3.41	3.44	3.16
M1 (Δ12)	3.50	2.48	2.69	3.97	3.83	4.31
M2 (Δ3)	3.60	2.64	3.65	3.19	3.24	2.85
M2 (Δ12)	3.58	3.56	3.49	3.23	3.83	3.17
M3 (Δ3)	3.60	2.37	2.81	2.71	2.92	2.68
M3 (Δ12)	3.58	2.43	3.43	2.35	2.57	2.49
OIL (Δ3)	3.59	2.54	3.28	3.06	3.33	2.81
OIL (Δ12)	3.57	2.71	3.32	3.25	2.99	2.64
STOX (Δ3)	3.62	3.48	3.56	3.29	3.45	2.98
STOX (Δ12)	3.56	3.08	3.31	3.16	3.65	2.95
FEER (Δ12)	3.53	2.82	3.32	3.09	3.12	2.99
RV_USDEUR	3.59	3.71	4.25	3.48	3.12	2.97
RV_STN	3.58	2.95	3.05	2.78	2.76	2.75
RV_STOX50	3.58	3.32	3.61	3.28	3.04	2.73
DI_EX	3.56	2.90	3.25	2.67	1.85	2.13
CO_IN	3.62	3.36	2.67	3.07	3.45	3.07
LTN	3.55	2.94	3.52	3.30	4.65	4.89
YIELDC	3.53	2.04	2.37	2.65	3.37	2.98

	DC					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	45.83	83.33	77.08	81.25	70.83	56.25
UNI	70.83	89.58	89.58	100.00	100.00	100.00
LAR	70.83	85.42	87.50	91.67	100.00	100.00
AAA_1_3	70.83	89.58	89.58	100.00	100.00	100.00
AA_1_3	70.83	89.58	87.50	100.00	100.00	100.00
A_1_3	72.92	89.58	89.58	100.00	100.00	100.00
BBB_1_3	70.83	89.58	89.58	100.00	97.92	100.00
AAA_3_5	64.58	75.00	79.17	97.92	100.00	100.00
AA_3_5	68.75	85.42	66.67	100.00	100.00	100.00
A_3_5	68.75	89.58	89.58	100.00	100.00	100.00
BBB_3_5	70.83	89.58	89.58	100.00	100.00	100.00
AAA_5_10	70.83	89.58	89.58	100.00	100.00	100.00
AA_5_10	70.83	89.58	89.58	100.00	100.00	100.00
A_5_10	68.75	87.50	89.58	100.00	100.00	100.00
BBB_5_10	70.83	89.58	89.58	100.00	100.00	100.00
AAA_7_10	68.75	89.58	89.58	100.00	100.00	100.00
AA_7_10	72.92	89.58	89.58	100.00	100.00	100.00
A_7_10	68.75	87.50	89.58	100.00	100.00	100.00
BBB_7_10	70.83	89.58	89.58	100.00	100.00	100.00
AAA_10_30	68.75	66.67	70.83	97.92	100.00	100.00
AA_10_30	64.58	83.33	85.42	100.00	100.00	100.00
A_10_30	64.58	70.83	79.17	100.00	100.00	100.00
M1 (Δ3)	66.67	89.58	89.58	100.00	100.00	100.00
M1 (Δ12)	68.75	89.58	89.58	97.92	100.00	100.00
M2 (Δ3)	56.25	89.58	89.58	100.00	100.00	100.00
M2 (Δ12)	66.67	89.58	87.50	100.00	100.00	100.00
M3 (Δ3)	62.50	83.33	89.58	100.00	100.00	100.00
M3 (Δ12)	62.50	89.58	87.50	100.00	100.00	100.00
OIL (Δ3)	70.83	81.25	89.58	100.00	100.00	100.00
OIL (Δ12)	68.75	89.58	89.58	100.00	100.00	100.00
STOX (Δ3)	72.92	89.58	89.58	100.00	100.00	100.00
STOX (Δ12)	75.00	89.58	89.58	89.58	91.67	100.00
FEER (Δ12)	62.50	83.33	85.42	100.00	100.00	100.00
RV_USDEUR	68.75	89.58	89.58	100.00	100.00	100.00
RV_STN	70.83	89.58	85.42	100.00	100.00	100.00
RV_STOX50	72.92	89.58	89.58	100.00	100.00	100.00
DI_EX	60.42	81.25	70.83	75.00	70.83	79.17
CO_IN	72.92	89.58	81.25	100.00	100.00	100.00
LTN	64.58	89.58	89.58	100.00	100.00	100.00
YIELDC	68.75	89.58	89.58	100.00	100.00	100.00

Table 11: RMSE and DC, Crisis period (January 2008 – December 2009)

RMSE						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	1.07	3.18	7.06	11.12	13.64	15.98
UNI	1.33	3.54	8.22	12.33	13.93	14.77
LAR	1.03	3.62	12.16	13.58	10.93	10.92
AAA_1_3	1.14	3.12	7.98	10.60	12.18	13.29
AA_1_3	1.28	3.72	9.64	9.79	10.33	12.00
A_1_3	1.28	3.88	11.02	10.50	10.84	12.66
BBB_1_3	1.34	3.77	8.51	11.33	13.39	14.58
AAA_3_5	1.24	3.57	8.70	12.65	13.93	14.47
AA_3_5	1.20	3.33	8.52	11.31	12.66	13.16
A_3_5	1.27	3.76	9.99	10.07	11.60	12.94
BBB_3_5	1.28	3.51	8.22	11.06	13.12	14.46
AAA_5_10	1.21	3.26	8.11	10.19	11.84	13.12
AA_5_10	1.23	3.28	8.23	8.94	10.18	11.74
A_5_10	1.20	3.26	8.86	9.33	9.53	11.21
BBB_5_10	1.32	3.94	10.17	9.95	11.67	13.00
AAA_7_10	1.28	3.60	8.92	10.84	12.42	13.48
AA_7_10	1.25	3.40	8.58	8.88	9.74	11.22
A_7_10	1.22	3.39	9.35	9.77	8.99	10.77
BBB_7_10	1.32	3.91	9.96	10.33	12.26	13.52
AAA_10_30	1.24	3.50	8.41	12.19	13.71	14.43
AA_10_30	1.25	3.40	8.67	12.14	13.58	14.02
A_10_30	1.32	3.80	9.71	12.18	13.59	14.14
M1 (Δ3)	1.35	3.51	7.96	11.77	13.13	13.86
M1 (Δ12)	1.27	3.04	6.31	9.73	11.22	12.49
M2 (Δ3)	1.27	3.44	8.01	12.63	14.50	15.54
M2 (Δ12)	1.30	3.52	8.30	14.21	16.47	17.14
M3 (Δ3)	1.31	3.45	7.91	12.20	13.74	14.41
M3 (Δ12)	1.30	3.41	7.65	11.87	13.03	13.11
OIL (Δ3)	1.27	3.43	8.12	12.36	14.11	14.95
OIL (Δ12)	1.38	3.59	8.27	12.47	14.01	14.77
STOX (Δ3)	1.24	3.02	7.26	11.67	13.45	14.52
STOX (Δ12)	1.33	3.34	7.38	11.87	13.61	14.64
FEER (Δ12)	1.35	3.51	7.80	12.28	14.05	15.04
RV_USDEUR	1.31	3.54	8.27	12.52	14.56	15.89
RV_STN	1.34	3.55	8.20	12.32	13.93	14.89
RV_STOX50	1.23	3.28	7.88	12.14	13.94	14.88
DI_EX	1.35	3.48	7.19	10.55	11.16	12.06
CO_IN	1.35	3.55	8.03	12.50	13.76	14.38
LTN	1.34	3.54	8.20	12.46	14.16	15.23
YIELDC	1.24	3.17	6.82	11.34	13.02	13.88

RMSE RATIOS						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD						
UNI	1.24	1.11	1.16	1.11	1.02	0.92
LAR	0.96	1.14	1.72	1.22	0.80	0.68
AAA_1_3	1.07	0.98	1.13	0.95	0.89	0.83
AA_1_3	1.19	1.17	1.36	0.88	0.76	0.75
A_1_3	1.20	1.22	1.56	0.94	0.79	0.79
BBB_1_3	1.25	1.18	1.21	1.02	0.98	0.91
AAA_3_5	1.16	1.12	1.23	1.14	1.02	0.91
AA_3_5	1.12	1.05	1.21	1.02	0.93	0.82
A_3_5	1.19	1.18	1.41	0.91	0.85	0.81
BBB_3_5	1.19	1.10	1.16	0.99	0.96	0.90
AAA_5_10	1.13	1.02	1.15	0.92	0.87	0.82
AA_5_10	1.14	1.03	1.17	0.80	0.75	0.74
A_5_10	1.12	1.03	1.26	0.84	0.70	0.70
BBB_5_10	1.23	1.24	1.44	0.89	0.85	0.81
AAA_7_10	1.19	1.13	1.26	0.98	0.91	0.84
AA_7_10	1.16	1.07	1.21	0.80	0.71	0.70
A_7_10	1.13	1.07	1.32	0.88	0.66	0.67
BBB_7_10	1.23	1.23	1.41	0.93	0.90	0.85
AAA_10_30	1.16	1.10	1.19	1.10	1.00	0.90
AA_10_30	1.16	1.07	1.23	1.09	1.00	0.88
A_10_30	1.23	1.19	1.38	1.10	1.00	0.89
M1 (Δ3)	1.26	1.10	1.13	1.06	0.96	0.87
M1 (Δ12)	1.19	0.96	0.89	0.88	0.82	0.78
M2 (Δ3)	1.18	1.08	1.13	1.14	1.06	0.97
M2 (Δ12)	1.22	1.11	1.18	1.28	1.21	1.07
M3 (Δ3)	1.22	1.08	1.12	1.10	1.01	0.90
M3 (Δ12)	1.21	1.07	1.08	1.07	0.96	0.82
OIL (Δ3)	1.18	1.08	1.15	1.11	1.03	0.94
OIL (Δ12)	1.29	1.13	1.17	1.12	1.03	0.92
STOX (Δ3)	1.16	0.95	1.03	1.05	0.99	0.91
STOX (Δ12)	1.24	1.05	1.04	1.07	1.00	0.92
FEER (Δ12)	1.26	1.10	1.11	1.10	1.03	0.94
RV_USDEUR	1.22	1.11	1.17	1.13	1.07	0.99
RV_STN	1.25	1.12	1.16	1.11	1.02	0.93
RV_STOX50	1.15	1.03	1.12	1.09	1.02	0.93
DI_EX	1.26	1.09	1.02	0.95	0.82	0.76
CO_IN	1.26	1.12	1.14	1.12	1.01	0.90
LTN	1.24	1.11	1.16	1.12	1.04	0.95
YIELDC	1.16	1.00	0.97	1.02	0.95	0.87

CW						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD						
UNI	1.31	0.93	0.18	-0.25	0.08	2.91
LAR	1.99	1.43	-1.24	0.37	2.38	3.07
AAA_1_3	1.46	2.18	-0.97	1.16	2.16	3.74
AA_1_3	1.29	-0.37	-1.42	1.85	2.70	3.25
A_1_3	1.46	0.19	-0.98	1.58	2.89	3.01
BBB_1_3	1.11	-0.35	-1.31	0.13	0.67	2.68
AAA_3_5	1.23	0.41	-1.61	-0.55	0.11	3.45
AA_3_5	1.36	0.81	-1.61	-0.04	1.55	3.24
A_3_5	1.28	-0.03	-1.18	1.49	2.19	2.68
BBB_3_5	1.23	0.28	-1.04	0.49	0.90	2.08
AAA_5_10	1.27	1.17	-1.08	1.90	2.67	3.90
AA_5_10	1.35	0.86	-0.85	2.31	2.83	3.25
A_5_10	1.39	0.76	-0.63	2.09	2.95	3.06
BBB_5_10	1.21	-0.30	-1.24	1.62	2.20	2.99
AAA_7_10	1.17	0.07	-1.62	0.97	1.91	3.59
AA_7_10	1.28	0.41	-0.89	2.21	2.80	3.07
A_7_10	1.36	0.53	-0.68	2.05	2.95	3.02
BBB_7_10	1.18	-0.10	-1.18	1.33	1.83	3.01
AAA_10_30	1.26	0.77	-0.77	-0.39	0.33	3.51
AA_10_30	1.41	0.93	-1.59	-0.49	0.52	3.89
A_10_30	1.15	-0.36	-2.15	-0.46	0.49	3.61
M1 (Δ3)	1.28	1.02	0.49	0.47	1.10	3.76
M1 (Δ12)	1.48	1.70	1.44	2.62	3.10	4.24
M2 (Δ3)	1.49	1.16	0.37	-0.66	-0.88	1.47
M2 (Δ12)	1.36	0.99	0.13	-2.07	-3.15	-1.67
M3 (Δ3)	1.42	1.17	0.50	-0.09	0.38	3.31
M3 (Δ12)	1.39	1.22	0.68	0.22	1.27	4.25
OIL (Δ3)	1.38	1.17	0.17	-0.50	-0.13	2.48
OIL (Δ12)	1.26	0.91	0.12	-0.44	0.00	2.92
STOX (Δ3)	1.50	1.77	0.81	0.21	0.62	2.86
STOX (Δ12)	1.39	1.13	0.74	0.01	0.43	3.13
FEER (Δ12)	1.33	1.08	0.67	-0.19	-0.08	2.40
RV_USDEUR	1.28	0.71	-0.27	-0.66	-1.14	0.43
RV_STN	1.31	0.93	0.22	-0.22	0.08	2.57
RV_STOX50	1.47	1.25	0.29	-0.24	0.02	2.42
DI_EX	1.35	1.30	1.28	1.95	2.34	3.49
CO_IN	1.26	0.89	0.45	-0.01	0.42	3.33
LTN	1.31	0.93	0.22	-0.38	-0.40	2.14
YIELDC	1.58	1.67	1.16	0.79	1.29	3.93

DC						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	83.33	75.00	58.33	50.00	37.50	25.00
UNI	58.33	50.00	29.17	16.67	16.67	20.83
LAR	83.33	70.83	54.17	37.50	58.33	62.50
AAA_1_3	58.33	62.50	50.00	45.83	41.67	37.50
AA_1_3	58.33	66.67	58.33	79.17	66.67	54.17
A_1_3	66.67	79.17	75.00	62.50	50.00	41.67
BBB_1_3	58.33	66.67	45.83	33.33	16.67	20.83
AAA_3_5	54.17	54.17	45.83	16.67	16.67	20.83
AA_3_5	58.33	66.67	54.17	33.33	25.00	37.50
A_3_5	54.17	75.00	70.83	62.50	50.00	41.67
BBB_3_5	58.33	70.83	54.17	37.50	25.00	25.00
AAA_5_10	58.33	66.67	66.67	58.33	45.83	37.50
AA_5_10	58.33	62.50	79.17	79.17	66.67	54.17
A_5_10	54.17	66.67	83.33	79.17	66.67	54.17
BBB_5_10	62.50	83.33	75.00	66.67	50.00	41.67
AAA_7_10	62.50	62.50	50.00	45.83	33.33	29.17
AA_7_10	58.33	58.33	83.33	79.17	66.67	58.33
A_7_10	54.17	58.33	75.00	83.33	70.83	58.33
BBB_7_10	62.50	83.33	75.00	62.50	45.83	33.33
AAA_10_30	62.50	54.17	41.67	20.83	16.67	20.83
AA_10_30	58.33	58.33	45.83	29.17	16.67	20.83
A_10_30	58.33	54.17	45.83	20.83	16.67	20.83
M1 (Δ3)	62.50	54.17	29.17	16.67	16.67	20.83
M1 (Δ12)	66.67	79.17	75.00	70.83	58.33	50.00
M2 (Δ3)	62.50	58.33	29.17	16.67	16.67	20.83
M2 (Δ12)	66.67	58.33	29.17	16.67	16.67	20.83
M3 (Δ3)	62.50	58.33	29.17	16.67	16.67	20.83
M3 (Δ12)	62.50	58.33	29.17	16.67	16.67	20.83
OIL (Δ3)	58.33	62.50	37.50	20.83	16.67	20.83
OIL (Δ12)	54.17	54.17	29.17	16.67	16.67	20.83
STOX (Δ3)	62.50	79.17	50.00	29.17	16.67	20.83
STOX (Δ12)	62.50	62.50	45.83	20.83	16.67	20.83
FEER (Δ12)	58.33	54.17	29.17	16.67	16.67	20.83
RV_USDEUR	62.50	50.00	41.67	16.67	16.67	20.83
RV_STN	58.33	50.00	29.17	16.67	16.67	20.83
RV_STOX50	66.67	50.00	41.67	20.83	16.67	20.83
DI_EX	54.17	58.33	54.17	70.83	66.67	58.33
CO_IN	58.33	54.17	25.00	16.67	16.67	20.83
LTN	58.33	54.17	29.17	16.67	16.67	20.83
YIELDC	58.33	70.83	45.83	25.00	16.67	20.83

Table 12: Continuously Ranked Probability Score (CRPS), full/pre-crisis/crisis period

CRPS - Full sample period						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	0.0971	0.0935	0.1401	0.1494	0.1729	0.1952
UNI	0.0921	0.1014	0.1627	0.1716	0.1827	0.1901
LAR	0.0792	0.0917	0.1500	0.1618	0.1452	0.1467
AAA_1_3	0.0865	0.0986	0.1511	0.1489	0.1665	0.1808
AA_1_3	0.0930	0.1106	0.1566	0.1399	0.1483	0.1695
A_1_3	0.0912	0.1000	0.1428	0.1364	0.1469	0.1670
BBB_1_3	0.0943	0.1083	0.1566	0.1534	0.1723	0.1776
AAA_3_5	0.0914	0.1111	0.1697	0.1773	0.1839	0.1899
AA_3_5	0.0898	0.1051	0.1605	0.1625	0.1745	0.1790
A_3_5	0.0908	0.1026	0.1500	0.1425	0.1561	0.1677
BBB_3_5	0.0926	0.1056	0.1524	0.1496	0.1677	0.1744
AAA_5_10	0.0901	0.1027	0.1515	0.1423	0.1581	0.1749
AA_5_10	0.0915	0.1026	0.1450	0.1303	0.1429	0.1632
A_5_10	0.0901	0.0983	0.1391	0.1276	0.1346	0.1554
BBB_5_10	0.0943	0.1072	0.1519	0.1401	0.1571	0.1668
AAA_7_10	0.0927	0.1093	0.1619	0.1524	0.1660	0.1783
AA_7_10	0.0922	0.1040	0.1443	0.1290	0.1376	0.1573
A_7_10	0.0906	0.1000	0.1388	0.1242	0.1303	0.1526
BBB_7_10	0.0933	0.1055	0.1498	0.1441	0.1630	0.1745
AAA_10_30	0.0901	0.1057	0.1692	0.1734	0.1843	0.1909
AA_10_30	0.0908	0.1032	0.1664	0.1677	0.1792	0.1847
A_10_30	0.0943	0.1137	0.1756	0.1695	0.1798	0.1853
M1 (Δ3)	0.0932	0.1004	0.1579	0.1645	0.1738	0.1803
M1 (Δ12)	0.0890	0.0890	0.1311	0.1360	0.1483	0.1595
M2 (Δ3)	0.0923	0.0989	0.1593	0.1734	0.1853	0.1945
M2 (Δ12)	0.0913	0.0983	0.1576	0.1805	0.1956	0.2019
M3 (Δ3)	0.0926	0.1000	0.1596	0.1726	0.1817	0.1881
M3 (Δ12)	0.0925	0.0998	0.1552	0.1710	0.1797	0.1822
OIL (Δ3)	0.0894	0.0990	0.1615	0.1695	0.1823	0.1904
OIL (Δ12)	0.0928	0.1012	0.1632	0.1712	0.1837	0.1929
STOX (Δ3)	0.0872	0.0880	0.1450	0.1624	0.1763	0.1864
STOX (Δ12)	0.0909	0.0976	0.1466	0.1650	0.1791	0.1848
FEER (Δ12)	0.0929	0.1010	0.1567	0.1709	0.1826	0.1904
RV_USDEUR	0.0918	0.1019	0.1623	0.1720	0.1851	0.1968
RV_STN	0.0922	0.1017	0.1639	0.1736	0.1842	0.1924
RV_STOX50	0.0872	0.0939	0.1547	0.1668	0.1821	0.1926
DI_EX	0.0937	0.1011	0.1465	0.1591	0.1644	0.1758
CO_IN	0.0927	0.1011	0.1615	0.1750	0.1812	0.1847
LTN	0.0930	0.1011	0.1593	0.1605	0.1655	0.1735
YIELDC	0.0899	0.0952	0.1414	0.1632	0.1753	0.1840

CRPS - Pre-crisis period						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	0.1557	0.1411	0.2091	0.2372	0.2352	0.2315
UNI	0.1084	0.1238	0.1896	0.2471	0.2581	0.2776
LAR	0.1119	0.1329	0.1775	0.2578	0.2098	0.2087
AAA_1_3	0.1092	0.1253	0.1905	0.2397	0.2534	0.2839
AA_1_3	0.1107	0.1270	0.1910	0.2312	0.2431	0.2774
A_1_3	0.1066	0.1215	0.1762	0.2043	0.2118	0.2376
BBB_1_3	0.1059	0.1172	0.1681	0.2031	0.2050	0.2081
AAA_3_5	0.1113	0.1359	0.2131	0.2657	0.2673	0.2854
AA_3_5	0.1108	0.1345	0.2151	0.2682	0.2683	0.2792
A_3_5	0.1080	0.1225	0.1810	0.2122	0.2170	0.2322
BBB_3_5	0.1067	0.1180	0.1673	0.1948	0.1927	0.1951
AAA_5_10	0.1074	0.1233	0.1816	0.2183	0.2327	0.2610
AA_5_10	0.1095	0.1268	0.1869	0.2192	0.2312	0.2581
A_5_10	0.1099	0.1290	0.1844	0.2089	0.2199	0.2404
BBB_5_10	0.1081	0.1243	0.1766	0.2048	0.2115	0.2169
AAA_7_10	0.1079	0.1262	0.1871	0.2311	0.2401	0.2671
AA_7_10	0.1101	0.1282	0.1862	0.2171	0.2255	0.2518
A_7_10	0.1113	0.1321	0.1874	0.2112	0.2239	0.2490
BBB_7_10	0.1080	0.1278	0.1792	0.2124	0.2238	0.2450
AAA_10_30	0.1110	0.1349	0.2104	0.2709	0.2739	0.2891
AA_10_30	0.1102	0.1248	0.1950	0.2491	0.2603	0.2830
A_10_30	0.1106	0.1289	0.1997	0.2531	0.2608	0.2773
M1 (Δ3)	0.1110	0.1256	0.1897	0.2309	0.2482	0.2609
M1 (Δ12)	0.1073	0.1226	0.1901	0.1995	0.2144	0.2241
M2 (Δ3)	0.1143	0.1305	0.1918	0.2389	0.2479	0.2705
M2 (Δ12)	0.1111	0.1189	0.1651	0.1893	0.2020	0.2424
M3 (Δ3)	0.1133	0.1361	0.2043	0.2619	0.2692	0.2875
M3 (Δ12)	0.1136	0.1383	0.2041	0.2731	0.2884	0.3069
OIL (Δ3)	0.1101	0.1284	0.1892	0.2368	0.2477	0.2724
OIL (Δ12)	0.1069	0.1216	0.1845	0.2400	0.2648	0.2907
STOX (Δ3)	0.1043	0.1134	0.1762	0.2297	0.2423	0.2662
STOX (Δ12)	0.1036	0.1146	0.1662	0.2292	0.2372	0.2464
FEER (Δ12)	0.1094	0.1283	0.1935	0.2451	0.2591	0.2766
RV_USDEUR	0.1091	0.1225	0.1793	0.2285	0.2304	0.2578
RV_STN	0.1085	0.1254	0.1990	0.2584	0.2680	0.2834
RV_STOX50	0.1044	0.1148	0.1761	0.2294	0.2538	0.2817
DI_EX	0.1126	0.1361	0.2085	0.2660	0.2789	0.2891
CO_IN	0.1092	0.1233	0.2058	0.2545	0.2625	0.2673
LTN	0.1108	0.1251	0.1729	0.1635	0.1631	0.1841
YIELDC	0.1129	0.1419	0.2122	0.2669	0.2754	0.2924

CRPS - Crisis period						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	0.1383	0.2338	0.3928	0.4483	0.5042	0.5575
UNI	0.1938	0.2808	0.4971	0.5299	0.5649	0.5880
LAR	0.1291	0.2340	0.4583	0.5379	0.5171	0.5124
AAA_1_3	0.1690	0.2680	0.4508	0.4697	0.5303	0.5606
AA_1_3	0.1972	0.3167	0.4725	0.4523	0.4641	0.5144
A_1_3	0.1971	0.2806	0.4276	0.4455	0.4634	0.5259
BBB_1_3	0.2125	0.3208	0.4915	0.4956	0.5585	0.5848
AAA_3_5	0.1875	0.3116	0.5070	0.5307	0.5652	0.5853
AA_3_5	0.1821	0.2865	0.4691	0.5007	0.5465	0.5512
A_3_5	0.1928	0.2908	0.4544	0.4666	0.5097	0.5384
BBB_3_5	0.2025	0.3084	0.4765	0.4918	0.5542	0.5842
AAA_5_10	0.1891	0.2881	0.4602	0.4629	0.5215	0.5623
AA_5_10	0.1923	0.2847	0.4300	0.4175	0.4590	0.5111
A_5_10	0.1852	0.2651	0.4080	0.4145	0.4258	0.4872
BBB_5_10	0.2077	0.3086	0.4667	0.4617	0.5189	0.5534
AAA_7_10	0.2002	0.3114	0.4978	0.4932	0.5434	0.5712
AA_7_10	0.1945	0.2897	0.4274	0.4145	0.4391	0.4879
A_7_10	0.1858	0.2698	0.4040	0.3985	0.4038	0.4677
BBB_7_10	0.2044	0.2993	0.4580	0.4704	0.5374	0.5682
AAA_10_30	0.1809	0.2893	0.5075	0.5244	0.5641	0.5866
AA_10_30	0.1867	0.2899	0.5075	0.5177	0.5628	0.5806
A_10_30	0.2018	0.3289	0.5400	0.5216	0.5634	0.5827
M1 (Δ3)	0.1951	0.2756	0.4780	0.5252	0.5590	0.5786
M1 (Δ12)	0.1829	0.2313	0.3766	0.4764	0.5205	0.5453
M2 (Δ3)	0.1811	0.2644	0.4824	0.5306	0.5660	0.5935
M2 (Δ12)	0.1850	0.2753	0.4981	0.5344	0.5698	0.6086
M3 (Δ3)	0.1853	0.2633	0.4735	0.5294	0.5632	0.5811
M3 (Δ12)	0.1852	0.2609	0.4570	0.5241	0.5531	0.5491
OIL (Δ3)	0.1775	0.2685	0.4923	0.5265	0.5662	0.5892
OIL (Δ12)	0.1976	0.2837	0.5011	0.5294	0.5649	0.5887
STOX (Δ3)	0.1768	0.2357	0.4371	0.5195	0.5630	0.5866
STOX (Δ12)	0.1988	0.2775	0.4501	0.5223	0.5604	0.5838
FEER (Δ12)	0.1965	0.2755	0.4698	0.5294	0.5662	0.5940
RV_USDEUR	0.1917	0.2885	0.5084	0.5305	0.5669	0.5996
RV_STN	0.1943	0.2812	0.4947	0.5300	0.5649	0.5904
RV_STOX50	0.1784	0.2621	0.4764	0.5249	0.5643	0.5892
DI_EX	0.1942	0.2679	0.4152	0.4934	0.5168	0.5302
CO_IN	0.1967	0.2833	0.4791	0.5319	0.5641	0.5805
LTN	0.1939	0.2805	0.4984	0.5338	0.5688	0.5992
YIELDC	0.1744	0.2374	0.3965	0.5170	0.5584	0.5758

Table 13: Rankings based on RMSE, DC, and CRPS – Full sample period (January 2004 – December 2009)

	RMSE					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	40	9	5	17	28	37
UNI	28	25	21	29	30	30
LAR	1	33	40	39	9	1
AAA_1_3	2	3	12	12	14	15
AA_1_3	16	34	34	5	5	7
A_1_3	17	38	39	11	6	10
BBB_1_3	33	35	26	16	18	18
AAA_3_5	13	32	30	38	32	29
AA_3_5	3	11	28	18	16	16
A_3_5	20	36	36	8	11	11
BBB_3_5	19	22	18	15	17	19
AAA_5_10	5	4	15	9	12	13
AA_5_10	8	7	19	2	4	5
A_5_10	4	6	31	3	2	3
BBB_5_10	27	39	38	6	10	9
AAA_7_10	15	31	32	14	15	17
AA_7_10	10	12	27	1	3	4
A_7_10	9	13	33	4	1	2
BBB_7_10	30	40	37	10	13	14
AAA_10_30	12	28	25	30	29	28
AA_10_30	11	14	29	25	25	25
A_10_30	26	37	35	26	24	24
M1 (Δ3)	38	20	11	21	19	20
M1 (Δ12)	14	2	1	7	7	8
M2 (Δ3)	24	15	13	37	38	38
M2 (Δ12)	25	21	24	40	40	40
M3 (Δ3)	32	19	10	27	27	27
M3 (Δ12)	31	16	7	23	21	12
OIL (Δ3)	21	17	16	32	35	33
OIL (Δ12)	39	30	22	34	34	31
STOX (Δ3)	6	1	4	20	22	26
STOX (Δ12)	23	10	6	22	23	23
FEER (Δ12)	36	23	8	28	36	36
RV_USDEUR	22	24	23	35	39	39
RV_STN	29	27	20	31	31	34
RV_STOX50	7	8	9	24	33	35
DI_EX	37	18	3	13	8	6
CO_IN	35	29	14	36	26	22
LTN	34	26	17	33	37	32
YIELDC	18	5	2	19	20	21

	CW					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD						
UNI	17	21	16	29	30	17
LAR	1	5	36	15	3	31
AAA_1_3	5	1	24	7	6	18
AA_1_3	27	35	35	13	14	32
A_1_3	14	33	28	14	9	30
BBB_1_3	39	37	29	19	20	2
AAA_3_5	30	27	33	38	33	15
AA_3_5	15	14	38	23	16	24
A_3_5	33	36	31	9	7	28
BBB_3_5	34	31	27	17	18	14
AAA_5_10	31	6	26	2	2	8
AA_5_10	25	18	23	3	8	29
A_5_10	22	28	21	8	11	35
BBB_5_10	37	38	32	6	10	26
AAA_7_10	36	32	37	11	4	7
AA_7_10	32	29	25	5	12	34
A_7_10	28	30	22	12	13	36
BBB_7_10	38	39	30	4	5	13
AAA_10_30	24	17	20	36	32	20
AA_10_30	7	2	34	32	24	5
A_10_30	35	34	39	34	25	9
M1 (Δ3)	19	20	9	18	17	4
M1 (Δ12)	10	4	1	1	1	3
M2 (Δ3)	3	13	11	37	37	33
M2 (Δ12)	11	19	18	39	39	39
M3 (Δ3)	6	15	8	26	28	16
M3 (Δ12)	9	11	7	22	22	27
OIL (Δ3)	12	10	13	33	36	21
OIL (Δ12)	29	22	17	31	35	22
STOX (Δ3)	4	3	4	20	21	12
STOX (Δ12)	13	9	5	25	27	10
FEER (Δ12)	21	16	6	27	31	19
RV_USDEUR	26	26	19	35	38	38
RV_STN	18	23	14	30	34	23
RV_STOX50	8	8	12	28	29	25
DI_EX	16	12	2	10	19	37
CO_IN	23	24	10	24	26	11
LTN	20	25	15	21	23	1
YIELDC	2	7	3	16	15	6

	DC					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	38	12	24	38	40	40
UNI	11	29	25	25	17	17
LAR	1	12	13	20	6	1
AAA_1_3	11	12	13	12	13	11
AA_1_3	11	9	11	2	2	4
A_1_3	2	3	4	8	8	8
BBB_1_3	11	9	17	15	37	17
AAA_3_5	36	38	31	38	17	17
AA_3_5	24	19	38	15	15	11
A_3_5	27	6	9	8	8	8
BBB_3_5	11	7	11	14	15	16
AAA_5_10	11	9	10	11	11	11
AA_5_10	11	12	3	2	2	4
A_5_10	27	12	1	2	2	4
BBB_5_10	6	1	4	6	8	8
AAA_7_10	11	12	13	12	14	15
AA_7_10	6	19	1	2	2	2
A_7_10	27	24	4	1	1	2
BBB_7_10	6	1	4	8	11	14
AAA_10_30	11	40	40	25	17	17
AA_10_30	31	33	22	17	17	17
A_10_30	31	39	31	20	17	17
M1 (Δ3)	24	24	25	25	17	17
M1 (Δ12)	6	3	4	6	6	7
M2 (Δ3)	38	19	25	25	17	17
M2 (Δ12)	11	19	31	25	17	17
M3 (Δ3)	31	33	25	25	17	17
M3 (Δ12)	31	19	31	25	17	17
OIL (Δ3)	11	33	22	20	17	17
OIL (Δ12)	27	24	25	25	17	17
STOX (Δ3)	5	3	13	17	17	17
STOX (Δ12)	2	12	17	40	39	17
FEER (Δ12)	36	36	35	25	17	17
RV_USDEUR	11	29	20	25	17	17
RV_STN	11	29	35	25	17	17
RV_STOX50	2	29	20	20	17	17
DI_EX	38	36	37	20	38	39
CO_IN	6	24	38	25	17	17
LTN	31	24	25	25	17	17
YIELDC	24	7	17	19	17	17

	CRPS					
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	40	4	4	13	19	38
UNI	21	23	34	32	33	30
LAR	1	3	13	19	5	1
AAA_1_3	2	10	15	12	16	20
AA_1_3	32	38	21	7	7	10
A_1_3	16	15	6	6	6	8
BBB_1_3	39	36	22	16	18	16
AAA_3_5	18	39	39	39	35	29
AA_3_5	7	31	29	21	21	18
A_3_5	13	26	14	10	9	9
BBB_3_5	26	33	18	14	17	12
AAA_5_10	10	28	16	9	11	14
AA_5_10	19	27	9	4	4	6
A_5_10	9	9	3	2	2	3
BBB_5_10	37	35	17	8	10	7
AAA_7_10	28	37	32	15	15	17
AA_7_10	22	30	7	3	3	4
A_7_10	12	16	2	1	1	2
BBB_7_10	35	32	12	11	12	13
AAA_10_30	10	34	38	35	37	33
AA_10_30	13	29	37	26	25	23
A_10_30	38	40	40	28	27	26
M1 (Δ3)	34	17	25	23	20	19
M1 (Δ12)	5	2	1	5	7	5
M2 (Δ3)	24	11	26	35	39	37
M2 (Δ12)	17	8	24	40	40	40
M3 (Δ3)	27	14	28	34	29	28
M3 (Δ12)	25	13	20	30	26	21
OIL (Δ3)	6	12	31	27	31	31
OIL (Δ12)	30	22	35	31	34	36
STOX (Δ3)	4	1	8	20	23	27
STOX (Δ12)	15	7	11	24	24	25
FEER (Δ12)	31	18	23	29	32	32
RV_USDEUR	20	25	33	33	38	39
RV_STN	23	24	36	37	36	34
RV_STOX50	3	5	19	25	30	35
DI_EX	36	19	10	17	13	15
CO_IN	29	20	30	38	28	24
LTN	33	21	27	18	14	11
YIELDC	8	6	5	22	22	22

Note: Orange, and dark and light-grey shaded cells indicate respective first, second, and third ranks with regard to the evaluation measure shown at the top of the tables.

Table 14: Rankings based on RMSE, DC, and CRPS – Pre-crisis period (January 2004 – December 2007)

RMSE						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	40	40	40	39	39	7
UNI	8	8	17	23	22	30
LAR	39	34	31	40	40	4
AAA_1_3	10	13	18	22	20	25
AA_1_3	15	11	15	18	14	21
A_1_3	7	3	3	3	4	6
BBB_1_3	17	12	5	4	2	1
AAA_3_5	29	36	37	32	31	37
AA_3_5	18	31	39	33	32	35
A_3_5	24	21	9	5	7	14
BBB_3_5	11	22	12	2	1	3
AAA_5_10	4	6	6	11	15	20
AA_5_10	12	9	10	8	11	16
A_5_10	23	24	21	12	9	10
BBB_5_10	26	30	24	13	3	2
AAA_7_10	5	14	14	10	16	26
AA_7_10	16	7	7	6	10	17
A_7_10	30	27	19	7	8	13
BBB_7_10	33	38	38	16	6	11
AAA_10_30	27	35	36	36	36	36
AA_10_30	13	23	27	26	27	34
A_10_30	22	29	29	29	23	28
M1 (Δ3)	32	20	16	21	21	23
M1 (Δ12)	6	26	34	34	26	5
M2 (Δ3)	38	28	22	20	18	27
M2 (Δ12)	31	4	32	1	5	15
M3 (Δ3)	34	32	25	31	29	29
M3 (Δ12)	37	37	33	37	37	18
OIL (Δ3)	36	33	20	27	19	33
OIL (Δ12)	19	19	4	17	25	32
STOX (Δ3)	1	1	2	14	12	24
STOX (Δ12)	2	2	1	25	13	8
FEER (Δ12)	21	25	23	24	34	40
RV_USDEUR	14	10	26	9	24	22
RV_STN	9	16	28	30	30	38
RV_STOX50	3	5	8	15	33	39
DI_EX	25	18	13	35	38	9
CO_IN	20	17	30	28	17	12
LTN	28	15	11	19	28	19
YIELDC	35	39	35	38	35	31

CW						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD						
UNI	17	15	12	26	28	29
LAR	11	36	31	14	5	1
AAA_1_3	23	16	13	25	25	31
AA_1_3	30	18	9	15	23	28
A_1_3	26	8	2	3	9	17
BBB_1_3	16	4	3	6	1	5
AAA_3_5	20	32	34	36	34	34
AA_3_5	32	27	37	38	36	30
A_3_5	33	11	7	8	10	9
BBB_3_5	21	7	8	10	3	4
AAA_5_10	34	22	20	18	15	13
AA_5_10	36	26	25	12	12	12
A_5_10	37	29	30	9	7	7
BBB_5_10	29	24	26	19	2	6
AAA_7_10	28	20	16	20	17	14
AA_7_10	38	25	24	7	11	11
A_7_10	39	33	29	4	8	10
BBB_7_10	31	31	39	22	6	8
AAA_10_30	9	21	33	39	38	38
AA_10_30	8	9	22	29	30	24
A_10_30	7	12	28	31	32	25
M1 (Δ3)	10	19	4	5	20	16
M1 (Δ12)	35	35	35	1	14	3
M2 (Δ3)	4	30	5	23	24	26
M2 (Δ12)	15	2	14	21	13	15
M3 (Δ3)	3	38	32	33	33	35
M3 (Δ12)	13	37	15	37	37	37
OIL (Δ3)	5	34	21	30	22	27
OIL (Δ12)	18	28	17	17	31	36
STOX (Δ3)	2	3	10	13	18	21
STOX (Δ12)	19	10	19	24	16	23
FEER (Δ12)	27	23	18	27	27	19
RV_USDEUR	6	1	1	2	26	22
RV_STN	12	13	27	32	35	32
RV_STOX50	14	6	6	16	29	33
DI_EX	22	17	23	34	39	39
CO_IN	1	5	36	28	19	18
LTN	24	14	11	11	4	2
YIELDC	25	39	38	35	21	20

DC						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	40	32	37	39	39	40
UNI	7	1	1	1	1	1
LAR	7	30	27	37	1	1
AAA_1_3	7	1	1	1	1	1
AA_1_3	7	1	27	1	1	1
A_1_3	2	1	1	1	1	1
BBB_1_3	7	1	1	1	37	1
AAA_3_5	31	38	35	34	1	1
AA_3_5	19	30	40	1	1	1
A_3_5	19	1	1	1	1	1
BBB_3_5	7	1	1	1	1	1
AAA_5_10	7	1	1	1	1	1
AA_5_10	7	1	1	1	1	1
A_5_10	19	28	1	1	1	1
BBB_5_10	7	1	1	1	1	1
AAA_7_10	19	1	1	1	1	1
AA_7_10	2	1	1	1	1	1
A_7_10	19	28	1	1	1	1
BBB_7_10	7	1	1	1	1	1
AAA_10_30	19	40	38	34	1	1
AA_10_30	31	32	31	1	1	1
A_10_30	31	39	35	1	1	1
M1 (Δ3)	29	1	1	1	1	1
M1 (Δ12)	19	1	1	34	1	1
M2 (Δ3)	39	1	1	1	1	1
M2 (Δ12)	29	1	27	1	1	1
M3 (Δ3)	35	32	1	1	1	1
M3 (Δ12)	35	1	27	1	1	1
OIL (Δ3)	7	36	1	1	1	1
OIL (Δ12)	19	1	1	1	1	1
STOX (Δ3)	2	1	1	1	1	1
STOX (Δ12)	1	1	1	38	38	1
FEER (Δ12)	35	32	31	1	1	1
RV_USDEUR	19	1	1	1	1	1
RV_STN	7	1	31	1	1	1
RV_STOX50	2	1	1	1	1	1
DI_EX	38	36	38	40	39	39
CO_IN	2	1	34	1	1	1
LTN	31	1	1	1	1	1
YIELDC	19	1	1	1	1	1

CRPS						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	40	40	37	22	16	9
UNI	14	17	25	29	27	26
LAR	38	30	15	27	10	5
AAA_1_3	16	21	26	25	25	32
AA_1_3	21	18	22	21	23	28
A_1_3	7	4	8	6	7	10
BBB_1_3	9	5	5	5	5	4
AAA_3_5	30	38	39	36	33	36
AA_3_5	26	35	40	38	36	30
A_3_5	11	8	17	11	9	7
BBB_3_5	8	7	3	4	2	2
AAA_5_10	6	9	13	13	15	18
AA_5_10	18	14	14	14	14	17
A_5_10	20	10	7	8	8	8
BBB_5_10	12	15	9	7	6	6
AAA_7_10	10	24	20	19	19	22
AA_7_10	19	13	10	12	13	16
A_7_10	25	16	4	9	11	12
BBB_7_10	17	29	16	10	12	11
AAA_10_30	28	37	38	40	38	37
AA_10_30	22	28	30	30	29	29
A_10_30	24	33	34	32	31	25
M1 (Δ3)	34	22	24	16	22	15
M1 (Δ12)	4	6	18	3	4	3
M2 (Δ3)	39	31	28	26	24	23
M2 (Δ12)	31	12	11	2	3	14
M3 (Δ3)	35	34	31	34	34	35
M3 (Δ12)	37	36	35	39	39	39
OIL (Δ3)	33	32	27	23	20	24
OIL (Δ12)	5	11	19	24	32	38
STOX (Δ3)	2	1	6	18	21	21
STOX (Δ12)	1	2	2	17	18	13
FEER (Δ12)	15	27	29	28	30	27
RV_USDEUR	23	19	23	15	17	19
RV_STN	13	26	32	33	35	32
RV_STOX50	3	3	12	20	26	31
DI_EX	32	25	21	37	40	40
CO_IN	27	20	33	31	28	20
LTN	29	23	1	1	1	1
YIELDC	36	39	36	35	37	34

Note: Orange, and dark and light-grey shaded cells indicate respective first, second, and third ranks with regard to the evaluation measure shown at the top of the tables.

Table 15: Rankings based on RMSE, DC, and CRPS – Crisis period (January 2008 – December 2009)

RMSE						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	2	5	3	16	26	39
UNI	32	26	20	31	30	31
LAR	1	33	40	39	7	2
AAA_1_3	3	3	12	13	13	15
AA_1_3	20	34	34	6	5	6
A_1_3	23	38	39	11	6	9
BBB_1_3	35	36	26	18	21	28
AAA_3_5	12	30	30	38	30	26
AA_3_5	4	10	27	17	16	14
A_3_5	18	35	37	8	10	10
BBB_3_5	21	23	19	15	19	25
AAA_5_10	6	6	15	9	12	13
AA_5_10	8	8	21	2	4	5
A_5_10	5	7	31	3	2	3
BBB_5_10	30	40	38	7	11	11
AAA_7_10	22	32	32	14	15	16
AA_7_10	14	13	28	1	3	4
A_7_10	7	12	33	5	1	1
BBB_7_10	28	39	36	10	14	17
AAA_10_30	10	20	25	27	27	24
AA_10_30	15	14	29	24	23	20
A_10_30	29	37	35	26	24	21
M1 (Δ3)	36	21	11	21	20	18
M1 (Δ12)	19	2	1	4	9	8
M2 (Δ3)	17	17	13	37	38	37
M2 (Δ12)	25	24	24	40	40	40
M3 (Δ3)	27	18	10	28	28	23
M3 (Δ12)	24	15	7	23	18	12
OIL (Δ3)	16	16	16	32	36	34
OIL (Δ12)	40	31	23	34	34	30
STOX (Δ3)	13	1	5	20	22	27
STOX (Δ12)	31	11	6	22	25	29
FEER (Δ12)	39	21	8	29	35	35
RV_USDEUR	26	25	22	36	39	38
RV_STN	34	28	17	30	30	33
RV_STOX50	9	9	9	25	33	32
DI_EX	38	19	4	12	8	7
CO_IN	37	29	14	35	29	22
LTN	33	27	18	33	37	36
YIELDC	10	4	2	19	17	19

CW						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD						
UNI	21	19	15	29	30	27
LAR	1	5	31	18	9	19
AAA_1_3	7	1	25	13	13	7
AA_1_3	24	39	34	8	7	15
A_1_3	8	32	26	10	4	24
BBB_1_3	39	37	33	21	21	30
AAA_3_5	34	30	36	36	29	12
AA_3_5	15	24	37	24	16	17
A_3_5	25	34	29	11	12	29
BBB_3_5	33	31	27	16	20	36
AAA_5_10	29	11	28	7	8	4
AA_5_10	18	23	23	2	5	16
A_5_10	12	26	20	4	3	21
BBB_5_10	35	36	32	9	11	25
AAA_7_10	37	33	38	14	14	9
AA_7_10	28	29	24	3	6	20
A_7_10	17	28	21	5	2	22
BBB_7_10	36	35	30	12	15	23
AAA_10_30	30	25	22	31	28	10
AA_10_30	10	20	35	34	23	5
A_10_30	38	38	39	33	24	8
M1 (Δ3)	26	15	9	17	19	6
M1 (Δ12)	5	3	1	1	1	2
M2 (Δ3)	4	12	11	37	37	37
M2 (Δ12)	16	16	17	39	39	39
M3 (Δ3)	9	10	8	25	27	14
M3 (Δ12)	13	8	6	19	18	1
OIL (Δ3)	14	9	16	35	35	32
OIL (Δ12)	31	21	18	32	33	26
STOX (Δ3)	3	2	4	20	22	28
STOX (Δ12)	11	13	5	22	25	18
FEER (Δ12)	20	14	7	26	34	34
RV_USDEUR	27	27	19	38	38	38
RV_STN	23	18	13	27	31	31
RV_STOX50	6	7	12	28	32	33
DI_EX	19	6	2	6	10	11
CO_IN	32	22	10	23	26	13
LTN	22	17	14	30	36	35
YIELDC	2	4	3	15	17	3

DC						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	1	6	11	13	15	17
UNI	18	37	30	28	19	19
LAR	1	8	13	16	7	1
AAA_1_3	18	16	17	14	14	12
AA_1_3	18	11	11	2	2	5
A_1_3	3	3	4	9	9	9
BBB_1_3	18	11	20	18	19	19
AAA_3_5	35	29	20	28	19	19
AA_3_5	18	11	13	18	17	12
A_3_5	35	6	9	9	9	9
BBB_3_5	18	8	13	16	17	17
AAA_5_10	18	11	10	12	12	12
AA_5_10	18	16	3	2	2	5
A_5_10	35	11	1	2	2	5
BBB_5_10	7	1	4	8	9	9
AAA_7_10	7	16	17	14	16	16
AA_7_10	18	21	1	2	2	2
A_7_10	35	21	4	1	1	2
BBB_7_10	7	1	4	9	12	15
AAA_10_30	7	29	26	23	19	19
AA_10_30	18	21	20	20	19	19
A_10_30	18	29	20	23	19	19
M1 (Δ3)	7	29	30	28	19	19
M1 (Δ12)	3	3	4	6	7	8
M2 (Δ3)	7	21	30	28	19	19
M2 (Δ12)	3	21	30	28	19	19
M3 (Δ3)	7	21	30	28	19	19
M3 (Δ12)	7	21	30	28	19	19
OIL (Δ3)	18	16	29	23	19	19
OIL (Δ12)	35	29	30	28	19	19
STOX (Δ3)	7	3	17	20	19	19
STOX (Δ12)	7	16	20	23	19	19
FEER (Δ12)	18	29	30	28	19	19
RV_USDEUR	7	37	26	28	19	19
RV_STN	18	37	30	28	19	19
RV_STOX50	3	37	26	23	19	19
DI_EX	35	21	13	6	2	2
CO_IN	18	29	40	28	19	19
LTN	18	29	30	28	19	19
YIELDC	18	8	20	22	19	19

CRPS						
Model	H=1	H=3	H=6	H=12	H=15	H=18
RWD	2	3	2	11	15	30
UNI	24	19	32	33	30	31
LAR	1	4	16	26	8	5
AAA_1_3	3	11	12	13	13	15
AA_1_3	30	38	22	5	5	6
A_1_3	23	24	6	6	6	8
BBB_1_3	40	39	28	18	23	27
AAA_3_5	13	35	39	35	32	25
AA_3_5	9	26	19	17	17	12
A_3_5	20	31	13	9	10	9
BBB_3_5	36	34	21	16	21	28
AAA_5_10	17	30	17	8	11	14
AA_5_10	22	29	9	4	4	4
A_5_10	12	12	5	3	2	3
BBB_5_10	39	36	18	7	12	13
AAA_7_10	34	37	33	15	16	16
AA_7_10	27	32	8	2	3	2
A_7_10	16	18	4	1	1	1
BBB_7_10	38	33	14	12	14	17
AAA_10_30	8	27	37	27	27	24
AA_10_30	14	28	38	21	24	19
A_10_30	37	40	40	25	25	21
M1 (Δ3)	28	14	25	23	20	20
M1 (Δ12)	10	2	1	10	9	10
M2 (Δ3)	11	8	26	38	38	38
M2 (Δ12)	15	13	30	40	40	40
M3 (Δ3)	19	9	24	29	28	23
M3 (Δ12)	18	7	15	22	18	11
OIL (Δ3)	7	10	29	30	36	34
OIL (Δ12)	35	23	35	34	33	32
STOX (Δ3)	5	1	10	20	22	26
STOX (Δ12)	33	15	11	24	26	29
FEER (Δ12)	31	16	20	31	35	36
RV_USDEUR	21	25	36	37	39	39
RV_STN	26	21	31	32	31	33
RV_STOX50	4	6	23	28	34	35
DI_EX	32	17	7	14	7	7
CO_IN	29	22	27	36	29	22
LTN	25	20	34	39	37	37
YIELDC	6	5	3	19	19	18

Note: Orange, and dark and light-grey shaded cells indicate respective first, second, and third ranks with regard to the evaluation measure shown at the top of the tables.

Table 16: Rank variation over time

LAR RANK AVERAGE						
Model	H=1	H=3	H=6	H=12	H=15	H=18
AAA_1_3	25	24	22	29	28	25
AA_1_3	23	26	20	27	12	11
A_1_3	20	28	27	34	28	21
BBB_1_3	19	17	21	24	30	22
AAA_3_5	23	25	24	6	10	16
AA_3_5	20	22	16	29	31	29
A_3_5	24	26	29	20	22	23
BBB_3_5	16	21	31	12	14	22
AAA_5_10	32	32	29	25	27	34
AA_5_10	31	27	28	35	25	32
A_5_10	33	32	34	27	29	20
BBB_5_10	30	23	17	5	3	3
AAA_7_10	16	30	28	26	31	33
AA_7_10	24	26	28	32	27	28
A_7_10	28	16	17	21	26	26
BBB_7_10	19	17	6	18	18	20
AAA_10_30	17	21	23	22	22	21
AA_10_30	20	18	22	16	17	17
A_10_30	23	9	12	16	33	28
M1 (Δ3)	19	23	23	23	25	20
M1 (Δ12)	20	9	2	1	2	4
M2 (Δ3)	3	12	20	21	20	23
M2 (Δ12)	23	16	8	19	16	20
M3 (Δ3)	25	13	7	26	22	24
M3 (Δ12)	17	22	26	22	7	7
OIL (Δ3)	4	4	10	4	7	9
OIL (Δ12)	11	19	15	10	19	22
STOX (Δ3)	3	1	4	24	24	16
STOX (Δ12)	10	9	20	25	17	21
FEER (Δ12)	14	17	25	25	23	21
RV_USDEUR	13	14	18	15	19	17
RV_STN	15	17	12	11	16	13
RV_STOX50	9	24	25	18	18	17
DI_EX	9	9	2	2	2	3
CO_IN	24	20	12	9	11	12
LTN	24	23	23	6	4	4
YIELDC	17	9	14	17	19	20

STRONGEST TREND TOWARDS HIGHER RANK						
Model	H=1	H=3	H=6	H=12	H=15	H=18
AAA_1_3	7	14	14	24	33	28
AA_1_3	26	9	32	7	6	4
A_1_3	18	19	8	28	12	2
BBB_1_3	8	7	23	34	22	24
AAA_3_5	10	33	2	31	11	14
AA_3_5	17	5	37	17	26	32
A_3_5	33	37	30	29	28	36
BBB_3_5	24	35	28	37	35	26
AAA_5_10	5	2	10	9	27	16
AA_5_10	20	16	15	23	37	7
A_5_10	34	10	4	11	25	22
BBB_5_10	32	31	34	13	9	12
AAA_7_10	16	3	21	16	8	33
AA_7_10	35	21	9	5	13	15
A_7_10	13	23	11	1	1	5
BBB_7_10	22	28	22	33	20	8
AAA_10_30	3	34	24	32	24	30
AA_10_30	14	24	13	2	4	3
A_10_30	9	30	18	8	23	35
M1 (Δ3)	25	8	36	6	3	10
M1 (Δ12)	15	12	33	18	14	11
M2 (Δ3)	37	6	5	35	36	27
M2 (Δ12)	12	11	27	3	5	1
M3 (Δ3)	11	36	35	15	7	31
M3 (Δ12)	19	20	1	26	31	19
OIL (Δ3)	36	32	25	30	16	9
OIL (Δ12)	21	1	3	4	2	18
STOX (Δ3)	4	18	16	21	17	34
STOX (Δ12)	27	29	17	36	29	29
FEER (Δ12)	30	13	7	22	32	37
RV_USDEUR	29	27	20	20	15	20
RV_STN	31	26	29	25	19	23
RV_STOX50	1	4	19	19	21	21
DI_EX	28	17	26	14	30	17
CO_IN	2	22	12	12	10	6
LTN	6	15	6	10	18	13
YIELDC	23	25	31	27	34	25

RANK BASED ON LAR RANK STD						
Model	H=1	H=3	H=6	H=12	H=15	H=18
AAA_1_3	36	34	31	24	26	34
AA_1_3	27	11	21	28	27	22
A_1_3	29	32	33	13	36	35
BBB_1_3	7	5	5	10	5	10
AAA_3_5	26	18	28	3	4	17
AA_3_5	22	19	36	20	12	6
A_3_5	15	7	9	7	7	15
BBB_3_5	5	10	10	11	14	33
AAA_5_10	9	17	16	27	24	4
AA_5_10	17	13	14	8	33	3
A_5_10	4	4	15	34	37	37
BBB_5_10	8	20	27	16	2	1
AAA_7_10	33	33	11	15	11	5
AA_7_10	25	31	19	14	20	12
A_7_10	24	27	29	32	35	30
BBB_7_10	21	22	7	9	6	11
AAA_10_30	10	24	35	37	32	27
AA_10_30	19	9	20	35	34	14
A_10_30	28	6	6	26	10	16
M1 (Δ3)	12	21	24	23	19	25
M1 (Δ12)	34	28	3	2	16	21
M2 (Δ3)	2	14	17	33	30	28
M2 (Δ12)	32	30	12	36	29	26
M3 (Δ3)	18	15	13	25	25	20
M3 (Δ12)	30	29	32	29	9	7
OIL (Δ3)	3	2	25	4	8	8
OIL (Δ12)	23	37	26	12	31	31
STOX (Δ3)	1	1	2	19	15	18
STOX (Δ12)	37	36	37	30	13	23
FEER (Δ12)	20	35	34	21	21	36
RV_USDEUR	6	3	22	22	22	24
RV_STN	14	16	4	5	18	9
RV_STOX50	13	26	23	17	17	13
DI_EX	11	25	1	1	1	19
CO_IN	35	12	8	6	23	29
LTN	16	23	18	18	3	2
YIELDC	31	8	30	31	28	32

Note: Orange, and dark and light-grey shaded cells indicate respective first, second, and third ranks with regard to the evaluation measure shown at the top of the tables. *LAR Rank Average:* is the average rank that each variable was assigned by LAR. *Strongest trend towards higher ranks*: is a ranking that is based on a trend computed from the recursively assigned LAR ranks. *Rank based on LAR Rank STD:* Rank based on standard deviation of LAR-assigned ranks (from highest to lowest).

Table 17: LAR model composition

How often were LAR-selected variables included in the model? (in percent)						
Model	H=1	H=3	H=6	H=12	H=15	H=18
AAA_1_3	0.14	0.08	0.00	0.00	0.00	0.00
AA_1_3	0.00	0.00	0.00	0.07	0.00	0.00
A_1_3	0.11	0.03	0.07	0.00	0.00	0.06
BBB_1_3	0.00	0.00	0.00	0.00	0.00	0.00
AAA_3_5	0.00	0.00	0.00	0.94	0.00	0.00
AA_3_5	0.00	0.00	0.06	0.04	0.00	0.00
A_3_5	0.00	0.00	0.00	0.06	0.00	0.00
BBB_3_5	0.00	0.00	0.00	0.32	0.00	0.06
AAA_5_10	0.00	0.00	0.00	0.00	0.00	0.00
AA_5_10	0.00	0.04	0.03	0.00	0.00	0.00
A_5_10	0.00	0.00	0.01	0.03	0.01	0.06
BBB_5_10	0.00	0.00	0.00	0.88	0.33	0.40
AAA_7_10	0.00	0.00	0.00	0.04	0.00	0.00
AA_7_10	0.00	0.00	0.03	0.03	0.00	0.00
A_7_10	0.01	0.07	0.10	0.10	0.00	0.00
BBB_7_10	0.07	0.14	0.15	0.25	0.00	0.00
AAA_10_30	0.00	0.00	0.00	0.28	0.00	0.00
AA_10_30	0.00	0.00	0.00	0.65	0.00	0.00
A_10_30	0.00	0.00	0.00	0.29	0.00	0.00
M1 (Δ3)	0.00	0.00	0.00	0.00	0.00	0.00
M1 (Δ12)	0.11	0.22	0.81	1.00	0.96	0.69
M2 (Δ3)	0.61	0.00	0.00	0.25	0.00	0.00
M2 (Δ12)	0.00	0.00	0.10	0.46	0.00	0.00
M3 (Δ3)	0.00	0.00	0.06	0.01	0.00	0.00
M3 (Δ12)	0.00	0.00	0.00	0.17	0.13	0.03
OIL (Δ3)	0.35	0.39	0.00	1.00	0.04	0.01
OIL (Δ12)	0.00	0.00	0.03	0.83	0.00	0.04
STOX (Δ3)	0.39	0.89	0.24	0.03	0.00	0.00
STOX (Δ12)	0.42	0.22	0.03	0.14	0.04	0.00
FEER (Δ12)	0.00	0.00	0.00	0.03	0.00	0.03
RV_USDEUR	0.00	0.00	0.00	0.24	0.00	0.03
RV_STN	0.00	0.00	0.00	0.29	0.00	0.00
RV_STOX50	0.14	0.00	0.00	0.08	0.00	0.00
DI_EX	0.00	0.22	0.68	1.00	0.63	0.74
CO_IN	0.00	0.00	0.03	0.88	0.00	0.00
LTN	0.00	0.01	0.00	0.88	0.29	0.29
YIELDC	0.08	0.11	0.03	0.35	0.00	0.00

LAR-selection, Ranks						
Model	H=1	H=3	H=6	H=12	H=15	H=18
AAA_1_3	5	8	17	32	9	13
AA_1_3	12	13	17	23	9	13
A_1_3	7	11	7	32	9	5
BBB_1_3	12	13	17	32	9	13
AAA_3_5	12	13	17	4	9	13
AA_3_5	12	13	8	25	9	13
A_3_5	12	13	17	24	9	13
BBB_3_5	12	13	17	12	9	5
AAA_5_10	12	13	17	32	9	13
AA_5_10	12	10	10	32	9	13
A_5_10	12	13	16	27	8	5
BBB_5_10	12	13	17	5	3	3
AAA_7_10	12	13	17	25	9	13
AA_7_10	12	13	10	27	9	13
A_7_10	11	9	5	21	9	13
BBB_7_10	10	6	4	16	9	13
AAA_10_30	12	13	17	15	9	13
AA_10_30	12	13	17	9	9	13
A_10_30	12	13	17	13	9	13
M1 (Δ3)	12	13	17	32	9	13
M1 (Δ12)	7	3	1	1	1	2
M2 (Δ3)	1	13	17	16	9	13
M2 (Δ12)	12	13	5	10	9	13
M3 (Δ3)	12	13	8	31	9	13
M3 (Δ12)	12	13	17	19	5	9
OIL (Δ3)	4	2	17	1	6	12
OIL (Δ12)	12	13	10	8	9	8
STOX (Δ3)	3	1	3	27	9	13
STOX (Δ12)	2	3	10	20	6	13
FEER (Δ12)	12	13	17	27	9	9
RV_USDEUR	12	13	17	18	9	9
RV_STN	12	13	17	13	9	13
RV_STOX50	5	13	17	22	9	13
DI_EX	12	3	2	1	2	1
CO_IN	12	13	10	5	9	13
LTN	12	12	17	5	4	4
YIELDC	9	7	10	11	9	13

Note: In the left panel – cells shaded in grey when respective variables are selected in more than 85% of the periods. Right panel: Orange, and dark and light-grey shaded cells indicate respective first, second, and third ranks.