

Recession Probabilities for the Eurozone at the Zero Lower Bound: Challenges to the Term Spread and Rise of Alternatives

Ralf Fendel, Nicola Mai, and Oliver Mohr

July 2018

Economics Group

Recession Probabilities for the Eurozone at the Zero Lower Bound: Challenges to the Term Spread and Rise of Alternatives

Ralf Fendel

WHU – Otto Beisheim School of Management

Nicola Mai

PIMCO

Oliver Mohr

WHU – Otto Beisheim School of Management, PIMCO

Working Paper 18/04
July 2018

ISSN 2511-1159

WHU - Otto Beisheim School of Management
Economics Group
Burgplatz 2
56179 Vallendar, Germany
Phone: +49 (261) 65 09 - 0
whu@whu.edu

Any opinions expressed here are those of the author(s) and not those of WHU. Research published in this series may include views on policy, but the institute itself takes no institutional policy positions.

WHU Working Papers often represent preliminary work and are circulated to encourage discussion. Citation of such a paper should account for its provisional character. A revised version may be available directly from the author.

Abstract

This paper examines the recession probabilities for the Eurozone along four different dimensions: First, we identify the best performing indicators for a recession within the next 12 months based on 43 underlying single variables and their different transformations in a benchmark model. We find that a modified version of the yield curve incorporating the shadow interest rate removes the downward rigidity of the front-leg and restores part of the informational content of the term spread at the zero lower bound. However, the best performing single indicator of the benchmark model is Real M1 followed by the Purchasing Managers Index (PMI), the investment grade corporate bond spread and the Terms of Trade. Second, the paper establishes three submodels to increase the lead-time and the stability of recession models: (i) Monetary transmission channels via principal component analysis; (ii) Bivariate regressions to identify paramount combinations; (iii) Unstable surges vis-à-vis the Hodrick-Prescott trend to detect animal spirits and hawkish mistakes. Third, the analysis is extended over various forecasting horizons (6m, 18m and 24m). Fourth, the results are analyzed from the perspective of risk-affine and risk-averse investors.

JEL-Classification: E3, E32, E37, E5, E58

Keywords: recession probability, term spread, zero lower bound, ECB, monetary transmission channel, animal spirits

Corresponding author:

Ralf Fendel, ralf.fendel@whu.edu

Recession Probabilities for the Eurozone at the Zero Lower Bound: Challenges to the Term Spread and Rise of Alternatives

Ralf Fendel*^a, Nicola Mai^b and Oliver Mohr^{a,b}

July 11, 2018

Abstract:

This paper examines the recession probabilities for the Eurozone along four different dimensions: First, we identify the best performing indicators for a recession within the next 12 months based on 43 underlying single variables and their different transformations in a benchmark model. We find that a modified version of the yield curve incorporating the shadow interest rate removes the downward rigidity of the front-leg and restores part of the informational content of the term spread at the zero lower bound. However, the best performing single indicator of the benchmark model is Real M1 followed by the Purchasing Managers Index (PMI), the investment grade corporate bond spread and the Terms of Trade. Second, the paper establishes three submodels to increase the lead-time and the stability of recession models: (i) Monetary transmission channels via principal component analysis; (ii) Bivariate regressions to identify paramount combinations; (iii) Unstable surges vis-à-vis the Hodrick-Prescott trend to detect animal spirits and hawkish mistakes. Third, the analysis is extended over various forecasting horizons (6m, 18m and 24m). Fourth, the results are analyzed from the perspective of risk-affine and risk-averse investors.

JEL Classification: E3, E32, E37, E5, E58

Keywords:

recession probability, term spread, zero lower bound, ECB, monetary transmission channel, animal spirits

^a WHU – Otto Beisheim School of Management

^b PIMCO

* Corresponding author: ralf.fendel@whu.edu

The views expressed in this paper are those of the authors and do not constitute official PIMCO views.

1. Introduction

The literature on predicting the likelihood of a recession provides broad consensus on the term spread as a reliable indicator for the binary state of the business cycle. Almost two decades after the formation of the European Monetary Union (EMU), data on the currency bloc challenges conventional wisdom through several dichotomies: A rather classical economic cycle characterized by the build-up of current account imbalances and overheating before the Global Financial Crisis (GFC) followed by a lackluster economy lingering in a liquidity trap and secular stagnation thereafter (Summers (2014)). Different monetary regimes ranging from orthodoxy and related hawkish mistakes were followed by unconventional monetary policy with a main refinancing rate pinned down at the zero lower bound (ZLB) and a neutral interest rate that potentially has declined substantially over time (Laubach and Williams (2015)). In addition, the brief history of the EMU is unique compared to other currency areas and the cohesiveness of the underlying economic region has been hostage to politicians, monetary policy makers and financial markets. The re-pricing of risks in periods of substantial convergence of EMU countries and increasing frictions after the GFC has affected financial market variables beyond their predictive value vis-à-vis the business cycle. These particularities of the Eurozone require that predictors of recession and expansion phases need to be sensitive enough to detect different types of economic cycles, insusceptible to varying central bank policies, and robust enough to withstand risks of re-denomination within the currency area.

The main purpose of this paper is to assess the likelihood of a recession in the Eurozone within the next 12 months along four dimensions: The first dimension focuses on the selection and the relevant transformation of input factors in univariate probit models representing the benchmark model of the analysis. On a second dimension, the paper introduces three submodels: First, we establish monetary transmission channels via principal component analysis to remove idiosyncratic influences and increase the indicators' robustness. Second, we combine the most predictive indicators from the benchmark model to identify paramount combinations. Third, we aim at modelling animal spirits and hawkish mistakes by constructing *unstable surge* indicators based on the deviation of the time series to its Hodrick-Prescott trend. The third dimension extends the analysis to three additional time horizons to analyze the lead-time of the input factors for the 6m, 18m, 24m forecasting periods. The fourth dimension models the utility for risk-affine and risk-averse market participants based on a loss-function to identify their preferred choices.

The paper proceeds as follows: In section 2, a literature review sheds light on empirical findings. Section 3 discusses theoretical considerations on why the term spread might be prone

to issue ambiguous signals in the current environment. Section 4 discusses the methodology and the dataset of the analysis. Section 5 reviews the benchmark model which is extended to the various submodels in section 6. Section 7 examines various time horizons and presents the results of an out-of-sample analysis. The paper concludes with a summary of key findings in section 8.

2. Literature Review

Given the binary classification of the business cycle into recessions and expansion phases, statistical procedures to predict the state of economic activity are inherently non-linear with probit models representing the most popular regression specification.¹ As the literature remains inconclusive about a superior type of modification², the main pivots for raising the predictive power of forecasting models have been the choice of input factors and their transformations. Hence, this section will classify existing studies on recession probabilities into their findings on the best performing explanatory variables, their regional perspective as well as their performance across various forecasting horizons and different transformations.

Regarding the explanatory variables, the slope of the yield curve has been associated with paramount predictive power for the future state of the business cycle. According to Estrella and Hardouvelis (1991), a positive term spread is a leading indicator for an expansion of consumption, investment and production. These results are underpinned by more recent research by Chauvet and Potter (2005), Rudebusch and Williams (2009) and Fornari and Lemke (2010). While the term spread has delivered strong predictive power across different pivots, Moneta (2005) examines ten variations of the yield curve (attachment points: 3m, 1yr, 2yr, 5yr, 10yr) and identifies the 3m-10yr yield curve as the most explanatory specification. Notwithstanding its widespread use, the term spread shows certain instability as the momentum of its inversion in the run-up to a recession can vary significantly with the type of economic downturn.

The inclusion of additional variables in multivariate probit models yields improved results. King et al. (2007) show that bivariate models of the investment grade (IG) or high-yield (HY) corporate bond spread in combination with the yield curve reduce the occurrence of false positive signals significantly. Based on theoretical considerations of Gilchrist and Zakrajšek

¹ A few studies also include logit regressions that produce similar results with slightly fatter tails of the probability distribution.

² Modifications to probit models yield partial improvements of results by including numerous states of the business cycle via multiple breakpoints in Markov-switching models (Dueker (1997), Levanon (2011), Chauvet and Potter (2005)), and VAR-augmented specifications (Fornari and Lemke (2010)).

(2012), Ergungor (2016) decomposes corporate bond spreads into two parts that reflect the expected default of the issuer³ and a general excess bond premium measured as the difference between the corporate spread and the expected default premium. While the excess bond premium turns out to be highly significant in predicting recessions, the additional yield implied by expected defaults does not display statistical significance. Confirming the predictive power of credit spreads, Fornari and Lemke (2010) also ascribe stock returns the ability to augment the forecasting performance of the term spread. In an analysis to predict economic turning points, Dovern and Ziegler (2008) find that corporate spreads, survey data, and composite indicators of real economic variables increase the forecasting quality. However, the authors cast doubts on stock returns that issue multiple false signals. In a study by Liu and Moench (2014), the term spread is paramount over various time horizons and its performance increases most notably in combination with the 1yr change of the S&P 500, Broker-Dealer margin accounts, the ISM (Institute of Supply Management) new order index and the NAPM (National Association of Purchasing Managers) index of consumer commodity prices. An additional source of useful indicators stems from the universe of corporate financial data such as the dividend yield (Bellego and Ferrara (2009)) and pre-tax corporate profits (Ergungor (2016)) whose interpretation is vulnerable to the informationally dilutive effect of the USD exchange rate.⁴

While aforementioned variables possess rather unambiguous correlation with the business cycle, the literature also identified a number of factors whose sign seems to be dependent on the respective region. As the majority of studies on recession probabilities focuses on the U.S., some researchers extend their perspective to a multi-country panel (Fornari and Lemke (2010) and Haltmaier (2008)), and only a few focus explicitly on the Eurozone or selected EU countries (Moneta (2005) and Bellego and Ferrara (2009)). According to Haltmaier (2008), exchange rates are broadly significant but the sign of their coefficients is ambiguous. While a real depreciation has mostly signaled a loss of confidence for developing countries (for example Mexico) coinciding with negative growth rates, in contrast a real appreciation has increased the recession probability for the UK and Taiwan whose open economies are more vulnerable to a loss of price competitiveness vis-à-vis the world. The same study shows that oil prices are significant for a selection of countries (U.S., the UK, Korea, and Taiwan) and insignificant for Canada and Mexico. A theoretical explanation lies in the cost-push effect for oil importing countries and the corresponding income-enhancing effect for oil-exporting

³ The expected default rate is calculated based on historical sensitivities.

⁴ As the USD serves as a flight to quality currency, the J-curve effect could lead to an initial increase in the sales value despite a deterioration of the economic environment.

nations. Variables falling short of predicting recessions have been gold prices, silver prices, treasury rates (King et al. (2007)) and broader monetary aggregates (except for M1). In particular, the forecasting power of real M2 has been in retreat since the late 1980s (Levanon et al. (2011)). The authors even identify a relationship that is inverse to the assumed causality with an increase of real M2 during the recession of 2001 and the GFC, potentially caused by de-regulation and structural changes of the banking sector.

The forecasting horizons covered by literature range from now-casting to up to 24 months. While results deteriorate for longer horizons, the predictive power of variables is the strongest for forecasting periods up to 12 months. However, shortening the forecasting horizon does not necessarily lead to improved results as the key determinant is the chronological relationship of the variable with the business cycle. Explanatory variables enter into statistical models as levels, changes over certain time periods (mostly 6m or 12m change) and lagged values. Procedures to reduce the dimensions of datasets have become increasingly popular. Predominantly based on principal component analysis, the use of indices as input factors yields the benefit of at least partly removing idiosyncratic characteristics of the underlying dataset (Levanon et al. (2011) and Chen et al. (2011)).

3. Conceptual Challenges to the Term Spread at the ZLB

From a conceptual perspective, the yield curve draws its explanatory value from two reinforcing sources: First, the inversion of the yield curve can be interpreted as a downward revision of market expectations on future real and nominal interest rates in the light of a decelerating economy. In line with the market expectations hypothesis, a decline of the long end of the interest rate curve reflects lower inflation expectations and dovish central bank policy that will be priced in at the first signs of a looming recession.

The second source of a flattening of the yield curve is monetary tightening in the boom phase of an economic cycle in order to contain inflationary pressures. As central banks have engaged in pre-emptive tightening to tackle inflation, short-term interest rates tend to rise faster than nominal interest rates in the mid-to-late cycle stage of an expansion, leading to a flattening of the curve.

At the ZLB, however, the shape of the yield curve as a predictor of the future state of the business cycle is compromised from two angles: The increasing use of forward guidance by central banks and a higher importance of the market segmentation theory in light of massive central bank asset purchases. Regarding the first aspect, central banks have indicated that future short-term interest rates would remain subdued for a pro-longed period of time. While this

forward guidance aimed at providing economic stimulus to escape the liquidity trap (Krugman (1998)) given dysfunctional fiscal and economic policy, markets incorporated the outlook on future policy rates into declining forward rates. While the conventional calibration of recession models using the term spread would be signaling elevated probabilities of an economic downturn, the cause for the flattening is actually a new monetary instrument in a low-growth environment.

The second differentiating characteristic at the ZLB is higher importance of the market segmentation hypothesis. While certain investors such as foundations, retail clients, hedge funds are less bound to certain maturity segments and asset classes, other investor groups like pension funds, insurance companies and foreign central banks are reliant on government bonds and certain maturity segments that serve their quality, liquidity and asset-liability matching needs. As these investors tend to stick to their preferred habitat, asymmetric bond purchases of certain maturities by a central bank create downward pressure of corresponding yield levels without a rotation out of these segments for higher risk-adjusted returns.⁵ Given that the main refinancing rate is already at the ZLB and the deposit facility faces a natural lower bound, both asymmetric and symmetric bond purchases will have a stronger effect on the long end of the curve than on the front-end.

4. Model Set-up and Data

4.1 Model Set-up

Research on recession probabilities refers commonly to the standard probit model specification to capture the binary state of the dependent variable and the continuous nature of input factors:

$$P(Y_{within(t+k)}) = \theta(\alpha_0 + \alpha_1' X_t), \quad [1]$$

where Y describes the binary state of the business cycle within the next $t+k$ months. If one of the next 12 months is defined as a recession month, Y takes the value of 1, otherwise, it is 0. The probit model is based on the standard normal cumulative density function θ . Thus, the model assumes non-linear behaviour of recession probabilities. α_0 denotes a constant term and α_1 represents the coefficients for the vector X_t which contains the input factors. In order to avoid over-specification and to be parsimonious, the following analysis only estimates

⁵ In particular, the repo market is dependent on collateral and the scarcity in government bond markets puts downward pressure on yields without containing predictive quality regarding upcoming recessions.

univariate and bivariate models. As compared to recession models that forecast the probability of a downturn “in” 12 months, this analysis is more useful in detecting the actual length of a recession at the expense of the leading nature of the model. As a remedy for this statistical trade-off, the analysis explicitly considers the 6m, 18m and 24m forecasting horizons to vary the lead-time of the calibration.

The baseline model of this paper covers a univariate specification of the standard probit regression and considers three transformations of the input factors (the level, the 6m change and the 12m change).⁶ In addition, the analysis establishes three submodels: The first submodel uses monetary transmission channels as input factors derived from a principal component analysis; the second submodel focuses on identifying superior bivariate model specifications; the third submodel aims at detecting unstable surges of economic developments to increase the lead-time of recession signals. The exact set-up of each submodel will be explained in greater detail at the onset of sections 6.1, 6.2 and 6.3.

4.2 Data

The analysis covers monthly observations for the time period between December 2001 and December 2017 based on data from Bloomberg and Haver. The binary dependent variable relies on the quarterly classification of the CEPR Euro Area Business Cycle Dating Committee which indicates that 33 months out of a total of 193 are classified as recession months.⁷ The Committee defines a recession as “*a significant decline in the level of economic activity, spread across the economy of the euro area, usually visible in two or more consecutive quarters of negative growth in GDP, employment and other measures of aggregate economic activity for the euro area as a whole.*” The concept to rely on a number of characteristics increases the resilience of the classification towards data revision and economic relevance.

As we focus on the probability of an economic downturn *within* a certain time period, the list of recession observations is modified to reflect the various forecasting horizons of 6m, 12m, 18m and 24m.⁸ The underlying dataset for the 43 explanatory variables [see Table 1 for the complete list] can be broadly classified into eleven categories: interest rates, the term spread, money supply, competitiveness, sentiment, refinancing conditions, preference for risk, industrial data, inflation, commodities and the wealth channel.

⁶ If the concept of the indicator does not allow for stationarity, the level is not included in the analysis.

⁷ Given the limited history of the Euro area, we associate single months with the quarterly classification of the CEPR instead of aggregating the monthly input factor to quarterly periodicity.

⁸ For example, the definition of a recession „within six months” requires the binary variable to signal a recession at time $t=0$ if $t+5$ is a recession month, although the economy might expand in $t+6$.

< Insert Table 1 >

The first three groups represent traditional channels of central bank policy via direct control of short-term *interest rates* and the *monetary base* as well as indirect control of the *shape of the yield curve*. To account for the downward rigidity of interest rates at the ZLB, a modified version of the term spread considers a shadow short-term rate (Wu and Xia (2016)) that allows for reaching deeply negative territories. The remaining eight segments of variables extend the narrow view of conventional central bank measures to a more diverse group of monetary transmission mechanisms and various other influences.

Varying in their leading, coinciding or lagging nature vis-à-vis the business cycle, the time series are selected based on the existing literature and theoretical considerations about their predictive quality. In addition to the level of the respective variables, the study includes their 6m and 12m changes⁹ to allow for different levels of sensitivity and to ensure reasonably mean-reverting characteristics in light of potential structural breaks.

4.3 Measurement of Results

Following the recent shift in literature away from model evaluation based on fit indicators¹⁰ to its actual classification ability, this paper assesses the quality of results from three different angles which are represented by a respective criterion: A signaling approach (Kaminsky and Reinhart (1999)), the area under the receiver operating curve (AUROC) and a loss function to model risk-averse and risk-seeking investors (Alessi and Detken (2009)).

The first criterion assumes that an indicator signals a recession when it surpasses the 50% threshold. Based on four categories, the signal is classified according to following matrix (Kaminsky and Reinhart (1999)):

	Recession within 12m	No Recession within 12m
Signal: Recession	A	B
Signal: No Recession	C	D

⁹ We either use the absolute difference between levels (“diff”) or the %-change between levels.

¹⁰ To assess the quality of results, models have predominantly relied on fit indicators such as the Bayesian Information Criterion (King et al. (2007)), different versions of R^2 (Chen et al. (2011) and Moneta (2005)) and other loss functions like quadratic/logarithmic probability scores (Chauvet and Potter (2005) and Levanon et al. (2011)).

We will discuss indicators along a variety of performance ratios, including the number of recession months detected, false alarms and the overall percentage of correct predictions.¹¹

As a remedy for the intuitive but somewhat arbitrary choice of the 50% threshold, this paper considers the area under the receiver operating curve (AUROC) as an alternative criterion. First introduced by Birdsall and Peterson (1953), this method was developed to express the diagnostic ability of a binary classifier system and has been recently used to describe the classification ability of business cycle indicators (Berge and Jordà (2011) and Liu and Moench (2014)). The centerpiece of this method is the receiver operating curve (ROC) which describes the ratio of true positive signals to false positive signals (i.e., false alarms) at various threshold values.

1. This method defines evenly spaced cut-off points, denoted as Ω , which determine whether to interpret the indicated likelihood p as a recession or an expansionary signal. The narrower the cut-off points are, the smoother is the ROC curve. The example below assumes ten thresholds with a distance of 0.1.

$$\Omega = [0, 0.1, 0.2, \dots, 0.8, 0.9, 1]$$

2. For each cut-off point, the process determines the ratio of true positive signals (TPS) to false alarms (FA).

$$TPS = \frac{1}{NR} \sum_{t=1}^T x; \text{ where } x = \begin{cases} 1, & p \geq \Omega \\ 0, & p < \Omega \end{cases} ; \text{ followed by a recession}$$

where NR describes the number of recession months

$$FA = \frac{1}{NE} \sum_{t=1}^T z; \text{ where } z = \begin{cases} 1, & p \geq \Omega \\ 0, & p < \Omega \end{cases} ; \text{ followed by an expansion}$$

where NE describes the number of expansion months

3. For each cut-off point, the procedure creates a coordinate in TPS-FA-space and connects these points to create the ROC. Coordinates above the 45% diagonal represent signals that are better than a random guess.
4. The AUROC is the integral of the area below the ROC.

The third criterion tries to shed light on the usefulness of indicators for different types of market participants following their relative preference of type 1 errors (missed recessions) versus type 2 errors (false alarm) along the lines of Alessi and Detken (2009). The one investor group that is rather sensitive to missing a recession will be labelled as *risk-averse*. The other

¹¹ The definitions of the various performance ratios are given in the heading of the respective performance tables in the Appendix.

group of market participants, described as *risk-affine*, is more concerned with false alarms which would detract from performance in the expansion phase. The loss function L of both investor groups is defined as follows:

$$L = \rho \frac{C}{A+C} + (1 - \rho) \frac{B}{B+D} . \quad [2]$$

For the risk-averse investor group, ρ is assigned a value of 0.75 (which increases the loss from undetected recessions). For risk-affine investors, we assume ρ to be 0.25 (which causes higher costs associated with false alarms).

5. Results of the Benchmark Model

This section highlights the challenges that the regime change of monetary policy at the ZLB is posing to the empirical supremacy of the term spread, suggests a remedy and then proceeds with a review of the best-performing indicators. Subsequently, the results are presented in a way that selected graphs displaying the probability level of indicating a recession for selected indicators (our first criterion) are included as figures (with panels for the selected indicators) in the main text body. The more detailed statistics on all indicators also including our second and third criteria are presented in corresponding tables in the Appendix [e.g., see Figure 1 and the corresponding Table A1 in the Appendix for our benchmark model].

< Insert Figure 1 >

While the recession of 2008-2009 still serves as a prime example for the ability of the term structure to forecast an economic downturn with sufficient lead-time¹², the indicator fails to capture the second recession beginning in 2011 [see Figure 1a]. To the contrary, the signal inches north in the aftermath of the European Sovereign Debt Crisis and remains elevated for the time period between 2015-2017 in the wake of a flattening of the interest rate curve induced by the Expanded Asset Purchase Programme by the ECB starting in 2015.

In an attempt to restore the informational content of the yield curve, we suggest a modified version of the term spread [see Figure 1a] that incorporates the shadow rate by Xia and Wu (2016) and removes the downward rigidity of the front-leg.¹³ As quantitative easing at

¹² The term spread signals a recession probability of above 50% as early as November 2006

¹³ To have a better comparison to the traditional version of the term spread, we use the EURIBOR instead of the EONIA as an input factor to the modified version.

the ZLB can be perceived as a substitute for further rate cuts, this revised indicator is composed of a variable front-leg that switches from the 3m Euribor to the shadow rate as soon as the ECB's policy rate hits the ZLB.¹⁴ Indeed, the ECB's unconventional monetary policy leads to a "shadow" steepening of the yield curve as the front-leg turns deep into negative territory. Hence, the average recession probability for the period between January 2015 and December 2017 recedes to 1% as compared to 40% as indicated by the traditional term spread.

The best performing indicator of the analysis is *high powered money* (12m change of Real M1), which reaches an almost perfect AUROC of 0.95, issuing 88% correct signals and detecting 73% of all recession months [see Table A1 in the Appendix]. In the run-up to both recessions, the indicator crosses the 50% threshold already 12 months before the start of each economic downturn [see Figure 1b]. Interestingly, Real M1 signals heightened recession risks around the near-crisis period at the beginning of last decade where economic growth had been lingering in negative territory for three months. Notwithstanding the fact that this time period did not technically qualify as a recession, these false positive signals underline the sensitivity of Real M1 to the economic cycle. Other aggregates of high powered money, M2 and M3, prove not to be useful as they are missing the leading character and are more exposed to other structural forces.

Slightly trailing the classification ability of Real M1, the second best performing cohort of variables is composed of indicators from sentiment indices, refinancing conditions, and measures of competitiveness. As the best indicator of the *sentiment* variables, the 12m change of the Purchasing Managers Index (PMI) [see Figure 1c and Table A1 in the Appendix] detects 60% of all crises with an AUROC of 0.88 and outperforms variables reflecting consumer or broader industrial surveys. Across all sentiment indices, the transformation to the 6m or 12m change has a significantly higher predictive value than the level due to a higher sensitivity to turning points. Regarding the recession of 2008-2009, the 12m change yields a lead time of 5m (3m for the second recession), while the level of the PMI first crosses a recession probability of 50% when the economy is already four months in recession (signal is coinciding with the start of the second recession).

Within the group of *refinancing conditions*, both spreads of investment grade (IG) corporate bonds and Eurozone peripheral sovereign bonds provide strong results [see Figure 1d and Table A1 in the Appendix]. Findings for the peripheral bond spread (12m change) indicate an AUROC of 0.85 and 49% of crisis detected. While the indicator is only somewhat flirting

¹⁴ The ZLB is defined as the situation where the lending facility is at 0% and the main refinancing rate hits 0.25% effectively limiting the space for further cuts (13th November 2013).

with the 50% threshold during the first recession, the variable issues strong recession signals as early as 16 months before the start of the second downturn, highlighting the causal relationship between tightening of financial conditions and economic growth in the Eurozone. This underlines the beneficial, dual characteristics of an indicator to reflect both a deteriorating endogenous business cycle and being itself a source for an exogenous shock. In light of the structural break in the wake of the Euro area crisis¹⁵, it turns out to be preferable to use the differenced time series as model input instead of the level. Particularly from the perspective of a risk-affine investor, this variable seems to be of use as it is less prone to non-systemic fluctuations with only 3% false positive recession signals [see Table A1 in the Appendix].

The IG corporate bond spread (level) yields an AUROC of 0.85 and detects 56% of recession months while issuing 7% false positive signals [see Table A1 in the Appendix]. The underperformance of high yield (HY) corporate spreads lends support to the critique of Gilchrist and Zakrajšek (2012) who suggest that the excess bond premium, and not the default risk premium, is the informative component about the future state of the economy. Since HY spreads are influenced to a stronger degree by the idiosyncratic default risk component, the actual sentiment among investors is reflected to a lesser degree.

In the *competitiveness* category, Terms of Trade detects 60% of crisis months with an AUROC of 0.85, moderately outperforming the FX EUR/USD rate (49% detected crisis and AUROC of 0.84) [see Figure 1e and Table A1 in the Appendix]. The strength of this indicator stems from the ability to include various characteristics such as the trade-weighted FX rate, import and export elasticities and the relative price of exports and imports. Periods of deterioration in the Terms of Trade can be a consequence of several events: a) shifts of global liquidity out of the EUR into USD-denominated safe haven assets b) higher commodity prices increasing production costs c) lower export prices depressing internal consumption and investments. All these potential drivers are associated with a decrease in real economic growth and the probit model, hence, considers a significant deterioration of the indicator as a harbinger of a recession. The indicator appeals in particular to risk-averse investors who accept a relatively high number of false alarms of 13% in exchange for the third highest number of recession months detected.

Results for the other categories are overall mixed with some noteworthy exceptions. Out of the indicators reflecting *Preference for Risk*, the level of implied interest rates volatility yields an AUROC of 0.79 and detects 51% of all crises [see Figure 1f and Table A1 in the

¹⁵ The first half of the last decade was characterized by a convergence process of sovereign bond yields and the assumption by capital markets that government debt of the Eurozone countries carried an implicit guarantee.

Appendix]. While the indicator is only coinciding with the first recession, the variable remains elevated in the preceding 14 months¹⁶ before the second economic downturn capturing the uncertainty in financial markets during the peripheral crisis of 2011-2013.

Two other indicators that are sensitive to investor's varying preference for risk are the Libor-OIS spread (AUROC of 0.82 and 53% detected crisis) [Figure 1f and Table 1A in Appendix] and the EUR/USD FX Basis¹⁷ (AUROC: 0.78 and 38% detected crisis; see Table A1 in the Appendix). As a non-EUR specific indicator, the Libor-OIS spread accurately signals the GFC with a lead of eight months. On the flipside of its global nature, the variable is only coinciding with the second economic downturn which was idiosyncratic to the Eurozone. In the end of 2016, however, the indicator reveals its vulnerability to dynamics surrounding the infrastructure of the interbanking market: The variable is falsely issuing a recession probability above 50% for seven consecutive months due to a U.S. money market reform that pushed U.S. investors from prime money market funds into U.S. treasuries. Likewise, the FX basis seems to generate reasonable results within the framework of this analysis.

A closer look at the fundamental drivers, however, reveals three, conceptually different periods of basis widening: At the height of the GFC, the breakdown of the covered interest rate parity was primarily driven by interbank market stress and USD shortage (Borio et al. (2016)). The second period from 2011-2014 can be characterized by increasing redenomination risks in the Eurozone and the corresponding ex-ante excess demand for USD vs. the EUR. While the beginnings of both periods were associated with the start of the two recessions, the subsequent third period was merely a reflection of ECB excess liquidity following the accelerated bond purchase program.¹⁸ Hence, the latest widening has erroneously sent out recession signals for most of 2016. Hence, we suggest the use of implied rates volatility as a more robust input factor over the Libor-OIS spread and the EUR/USD FX basis which are more immediate but also more prone to exogenous shocks that are unrelated to the business cycle. The category *Preference for Risk* performs clearly better for risk-averse investors due to the higher sensitivity than for the risk-affine investor type who perceives missing a crisis as less costly.¹⁹

The best performing variables in the *industrial data section* are retail sales (6m change) [see Figure 1g and Table A1 in the Appendix], stocks of finished products (6m change) and

¹⁶ The indicator dips briefly below the 50% threshold during those 14m.

¹⁷ The cross-currency basis is the basis spread added to the USD LIBOR to re-establish the covered interest rate parity between the EUR and the USD.

¹⁸ Main drivers of the EUR/USD FX Basis are identified as reverse Yankee bond issuance and EU investors looking for higher yields in the U.S. (Borio et al. (2016)).

¹⁹ Among the total of all 110 transformations tested, this category (level specification) ranks 38th for risk-averse investors and only 55th for risk-affine investors.

new cars (12m change) with an AUROC between 0.78-0.83 and detected crisis between 45% and 47%. Given their coinciding nature with the business cycle, these variables serve to confirm recessions rather than being leading indicators.

Among *inflation* measures, a positive change of the inflation rate is surprisingly associated with an increase of the recession probability. An explanation for the leading characteristic of inflation could be its ability to indicate an overheating of the economy which, in turn, could trigger monetary tightening by the central bank. Although results for the 12m change of the HICP are relatively strong with an AUROC of 0.82, the variable is vulnerable to policy changes of the inflation target and structurally subdued inflation dynamics [see Table A1 in the Appendix].

Within the *commodities* section, findings reveal that an increase in the oil price is associated with an increasing likelihood of recession [see Figure 1g and Table A1 in the Appendix]. Although the oil price provides strong summary statistics with an AUROC of 0.82 and 62% of all crisis detected, the recent two years have proven that idiosyncratic supply side dynamics can severely taint the variable's informational content on the endogenous business cycle. For risk-averse investors, the variable ranks 6th while risk-affine investors find less utility placing the input factor 41st given the highest number of false recession signals among all variables (15%). This underlines the need to analyze underlying drivers of this variable despite sound overall statistical results.

Representing the *wealth channel*, both building permits (6m change) and the EuroStoxx50 (12m change) [see Figure 1h and Table A1 in the Appendix] do not qualify as reliable indicators given low AUROCs of 0.76 and 0.69 and only 40% and 16% of recession months detected. Building permits merely capture the first recession given the strong credit expansion in the run-up to the GFC and the related overheating of the housing market but fail to reflect the second economic downturn in the Eurozone. Detractors of the predictive power of stock market returns are numerous significant price corrections. As most of them were not followed by recessions, the probit model adjusts by showing a lower overall magnitude of swings in recession probability, crossing the 50% threshold only during the sell-off in 2002 and the GFC. Hence, risk-affine investors should not be advised to consider these variables as indicators for economic downturns given aforementioned fluctuations in valuations metrics.²⁰

²⁰ The average results for the variables reflecting the wealth channel rank 63rd for risk-affine investors and 47th for averse agents.

6. Results of the Submodels

6.1 Submodel 1 – Monetary Transmission Channels

This submodel extracts the first principal component for categories representing different monetary transmission channels.²¹ The idea behind this approach is not necessarily to outperform the results of the benchmark model, but rather finding a specification that removes idiosyncratic vulnerabilities of single indicators. We construct eight monetary transmission channels: Money supply competitiveness, sentiment, refinancing, preference for risk, industrial data, inflation and commodities.²² Input factors are chosen based on a reasonable predictive quality in the previous univariate analysis. To ensure comparability among the different channels, we use all input factors in standardized form.²³

The analysis yields the strongest improvements for following groups: Preference for risk, industrial data, and refinancing variables. All three categories are composed of variables that are sensitive to the economic cycle, but at the same time prone to idiosyncratic factors. By extracting the first principal component, it is possible to reduce these non-systemic fluctuations and extract the common driver of variability in the dataset.

< Insert Figure 2 >

Regarding preference for risk [see Figure 2a and Table 2A in the Appendix], the channel achieves an AUROC of 0.86 versus an average of 0.80 for its subcomponents. This finding is supported by a surge in accurately called recessions from an average of 47% to 62% and a fall in the number of false positive signals to 5% (average of 7%). Since both the Libor-OIS spread and the FX Basis have shown its vulnerability to exogenous shocks that do not stem from the economic cycle, the signals of the monetary transmission channels prove to be more robust.

The study finds similar results for the refinancing channel with an improvement of the AUROC by 6pp to 0.88 versus the average of its subcomponents which are idiosyncratically exposed to risks from European fragmentation and the HY market structure [see Figure 2b and Table 2A in the Appendix]. We find that particularly risk-averse investors benefit from this submodel as the percentage of crisis detected increases to 69% from 53%. This result underlines

²¹ For the detailed results of the submodels with respect to our employed information criteria see again the respective tables in the Appendix, while the subsequent figures only highlight the best performing indicators with respect to their probabilities of predicting a recession.

²² We exclude interest rates, the term spread and a potential wealth channel given the lack of adequate input factors.

²³ Models consisting of more than two factors are established via principal component analysis, which requires standardization of the input factors.

the strength of the conceptual approach: While the HY and IG corporate bond spreads compensate for the failure of the Eurozone peripheral sovereign bond indicator during the first recession, the sustained positive recession signals of the latter in the run-up the second economic downturn is improving the channel's performance compared to the corporate spread variables.

Along the same lines, the channel of industrial variables indicates an improvement of the AUROC from an average of 0.80 to 0.89 of the combined model [see Figure 2c and Table 2A in the Appendix]. While new passenger cars and stocks of finished products do not serve as solid single indicators given a high number of false positive signals (average of 9%) and mediocre amount of crisis detected (average 46%), their combination with retails sales drives up the number of correctly predicted recessions to 65% and lowers the amount of false positive signals to 5%. Hence, even relatively volatile input factors can provide predictive value by their inclusion into existing models.

Regarding the competitiveness channel, we find a strong increase in accurately predicted recession months up to 71% from an average of 55% for the subcomponents [see Figure 2d and Table 2A in the Appendix]. The other monetary transmission channels (inflation, commodities, sentiment) yield results which are broadly in line with their underlying subcomponents. To provide insights into how much of the results is owed to the standardization of the variables, we included one model, *money supply*, which includes only one input factor. The results reveal that there is no material change as the AUROC improves marginally by 1pp [see Table A2 in the Appendix].

To conclude, the modeling of monetary transmission channels via principal component analysis yields significantly better results, in particular, for those channels whose subcomponents are most affected by idiosyncratic exogenous shocks. Besides statistical evidence, there is also a conceptual perspective that suggests higher future robustness associated with the use of aggregated channels even if results are in line with the underlying single input factors.

6.2 Submodel 2 – Bivariate Specification

The second modification estimates bivariate probit regressions based on the six best single indicators from the benchmark model [see Figure 3 and Table A3 in the Appendix for the results]. To ensure that the selected variables are not close substitutes but complementary in nature, the paper first identifies the leading indicators of the different categories and then considers the six best-performing variables in all possible combinations. The chosen leading

indicators are: Real M1 (12m change), PMI (12m change), IG corporate bond spread (level), Terms of Trade (level), retail sales (6m change) and the oil price (level). In a second step, we conduct a similar exercise for the monetary transmission channels that cover the following six variables: Money supply, sentiment, refinancing, competitiveness, industrial data, and commodities.

The results of the bivariate probit models improve the AUROC on average by 0.06 pp to 0.93 vis-à-vis the average performance of the single underlying indicators. The stronger performance is reflected in a surge of crisis detected by 17pp to 0.76 and a reduction of false signals by 2pp to 0.09.

< Insert Figure 3 >

The supreme combination is Real M1 and the PMI which reaches a near-perfect AUROC of 0.99 with 95% correct signals and 91% of crisis detected (missing only five recession months) [see Figure 3a and Table A3 in the Appendix]. All other combinations that include Real M1 or the PMI perform marginally worse but still significantly better than the single input factors. Beneficial for the combination of Real M1 and the PMI is the leading nature of Real M1 in the run-up to the first recession, whereas the PMI remains elevated somewhat longer during the recession. This combination of complementary characteristics enables the bivariate model to improve the lead-time and cover the length of the economic downturn more accurately. Besides the paramount performance of bivariate models that include either Real M1 or the PMI, the combination of IG corporate bond spreads and crude oil leads the ranking of other potential pairs closely followed by the pair of Terms of Trade and retail sales.

Results for the monetary transmission channels underline the findings for the single input factors. As the concept of transmission channels introduces a greater variety of variables, we find this procedure to be balancing the superior statistical performance of bivariate analysis while reducing the inherent risk of overfitting.

6.3 Submodel 3 – Unstable Surge

The third modification introduces the relative state of a variable versus its long-term trend in order to identify what Keynes termed “Animal Spirits” as well as potential hawkish mistakes by the central bank [see Table A4 in the Appendix for the results]. Traditional probit models tend to signal an elevated likelihood of a recession when indicators are deteriorating. However, the build-up of unsustainable momentum of economic developments can be an early indicator

of a looming correction following the possible collapse of over-optimism and inadequate production planning. Likewise, a hiking cycle which is too aggressive might be the harbinger of monetary tightening that has the potential to cause an economic downturn.

Hence, the idea is to detect periods of unstable surges measured against the Hodrick-Prescott (HP) trend estimated with a parameter value λ of 14,400 given the underlying monthly time series. The actual bivariate model consists of two input factors: 1) A single indicator that we conceptually suspect to describe these developments and 2) the deviation of this time series from its HP trend with three different lag structures (contemporaneous, with a 12m lag or a 24m lag). Potential indicators representing an overheating of the economy driven by animal spirits are: EuroStoxx50 (12m change), building permits (6m change), PMI (12m change), retail sales (6m change), MFI loans to the private sector (12m change) and crude oil (level). Input factors that are tested for their ability to detect a tightening of central bank policy are: Euribor (12m change), money supply (12m change) and inflation (12m change).

< Insert Figure 4 >

Among the variables tested, results for the PMI (contemporaneous version) yield a surge in the number of recession months detected by 22pp up to 82% [see Figure 4a and Table A4 in the Appendix]. The lead-time towards the first recession rises from five months to 14 months while there is no improvement for the second recession as the economic downturn starting in 2011 was not preceded by an overly optimistic outlook of producers.

Notwithstanding the fact that growth of MFI loans does not detect a single recession month in the baseline model, the augmentation incorporating the HP deviation (contemporaneous version) yields an AUROC of 0.81 and correctly identifies 47% of all crisis periods [Figure 4b and Table A4 in the Appendix]. In addition, this transformation shows a remarkable lead-time of six months before the GFC and eight months before the second recession. Findings for retail sales (contemporaneous version) indicate particular appeal for risk-averse investors whose utility rises significantly [Figure 4c and Table A4 in the Appendix]. While the AUROC increases by 0.07 to 0.90, the number of detected crisis almost doubles from 45% to 78%. The flipside of these results is a higher number of false positive signals of 14% (up from 6%) which could be too noisy for risk-affine agents.

Results for building permits underline the strength and the incompleteness of this variable [Figure 4d and Table A4 in the Appendix]. Statistics point to a strong improvement of the AUROC to 0.89 up from 0.76. However, this is mainly due to a more accurate reflection of

animal spirits in the run-up to the first recession. Given the lack of causality, the augmented indicator also misses out completely on the second economic downturn. Results for the other indicators do not show improved test statistics as both EuroStoxx50 and crude oil remain volatile, while the indicator of retail sales does not recede in between the two recessions.

With regard to hawkish mistakes by the central bank, we find that the augmented variable of the 3m Euribor carries predictive value [Figure 4g and Table A4 in the Appendix]. While the indicator does not call any recession month in the univariate benchmark model, the modification including a one-year lag results in an AUROC of 0.86 and 65% of recession months detected. The augmentation captures both recessions with a lead-time of ten months (first recession) and six months (second recession), indicating that an above-trend increase of the Euribor might signal the central bank's attempt to tighten monetary supply. In particular, the two hikes in the run-up to the second recession represent a poster model for a hawkish mistake. On the inflation variable, results suggest that a positive deviation from trend increases the probability of a recession [Figure 4h and Table A4 in the Appendix]. As above-trend inflation could induce a central bank to tighten rates, this indicator yields a moderate increase of recessions detected to 62% (up from 53%). Results for money supply are broadly in line with the univariate benchmark analysis with an AUROC inching slightly higher to 0.97 (up from 0.95).

To conclude, the addition of the deviation of indicators from their HP trend yields significant improvements for some of the variables as they are potential witnesses to unsustainable surges. Nevertheless, the results need to be interpreted with some caution as the HP trend is quite sensitive to the latest values of a time series and the ex-post analysis does not replicate a real-time assessment.

7. Out-of-Sample Analysis and Varying Time Horizons

7.1 Out-of-Sample Analysis

The out-of-sample test is calibrated for the time period between December 2001 and August 2010. Hence, it covers the period leading up to the GFC, the full length of the first recession and 14 months of the subsequent expansion phase, leaving a buffer of 13 months until the start of the second recession. The detailed results for the benchmark model are displayed in Table A5 in the Appendix, while Tables A6 through A8 in the Appendix show the result of the out-of-sample analysis for the three submodels.

Regarding the univariate benchmark model, the analysis allows a broad classification into two groups of indicators: Those variables that are rather unspecific in nature and a

reflection of broader business cycle dynamics as well as those indicators that are specific to the respective recession. Indicators that display the ability to capture both recessions are Real M1, the PMI, retail sales, implied interest rate volatility, the Libor-OIS spread, and crude oil whose summary statistics are similar to those of the benchmark model from section 5. Variables falling short of predicting both economic downturns are the term spread, the Eurozone peripheral sovereign bond spread, inflation and building permits. In particular the Eurozone peripheral sovereign bond spread underlines the necessity to qualitatively assess the probability of potential structural breaks: While investors have assumed an implicit guarantee of Eurozone government debt by other members of the currency bloc before the European debt crisis, the indicator has become functional after markets have revised this assumption in light of redenomination risks. On the same note, the potential formation of a European Monetary Fund, as currently discussed by policymakers, could represent a development that decreases the predictive quality of the indicator given lower sensitivity of spread levels.

7.2 The Benchmark Model over Various Time Horizons

To introduce an additional dimension, the analysis modifies the forecasting horizon to 6m, 18m and 24m to shed further light on the leading, coinciding or lagging nature of potential indicators.

For the 6m forecasting horizon, both industrial data and sentiment indicators gain substantially in predictive quality [see Table A9 in the Appendix for the details]. The PMI (12m change) becomes the best performing indicator with an AUROC of 0.95 (+0.07)²⁴ and 74% of crisis detected (+14pp). This result is reflective for the broader group of sentiment variables whose AUROCs increase to an average of 0.86 (up from 0.73). With regard to the category of industrial variables, we find very strong performance of retail sales (6m change) and stocks of finished products (12m change) whose AUROCs increase to 0.90 (+0.07) and 0.89 (+0.12) respectively on the back of better crisis detection and less false positive signals. Findings for both categories emphasize their particular usefulness in validating recessions given their shorter lead-time. Both buildings permits and the EuroSTOXX50 improve their results for the 6m horizon but still clearly underperform other indicators. For the other categories, we find a tendency of fewer crises detected and less false signals. As a consequence, models covering shorter time horizons provide a valuable perspective for risk-affine investors who face higher costs of false positive signals.

For the 18m horizon [see Table A10 in the Appendix], sentiment indicators and industrial data deteriorate across the board and lose out on their predictive capabilities, while

²⁴ The number in brackets indicates the relative change to the results of the 12m forecasting horizon.

financial market spread indicators closely track Real M1 as the best performing variables due to their longer-lead time. As to the forecasting ability of Real M1, the percentage of crisis detected remains practically unchanged at 75% versus the benchmark model, but false positive signals increase by 10pp to 15%. A common observation for the 18m forecasting horizon is a higher number of false positive signals which raises particularly the costs for the risk-affine investor type.

Considering the 24m forecasting horizon, findings indicate that it is hardly possible to achieve reliable forecasting performance [see Table A11 in the Appendix]. In particular, the number of false alarm surges across the dataset, declaring on average 18% of all expansion months to recessions (versus 3% for the 12 month forecasting horizon). Only two variables stand out with a slight deterioration against the 18m horizon: Both the peripheral sovereign spread and the IG corporate bond spread yield only moderately weaker results and could serve risk-averse investors as early warning indicators with a considerable lead-time.

7.3 Submodels over Various Time Horizons

Considering the first submodel, results indicate superior performance of the monetary transmission channels incorporating industrial data, sentiment variables and money supply with AUROCs between 0.95 and 0.93 and 72% to 70% of recession months correctly called²⁵ [see Table A12 in the Appendix for all time horizons]. Looking at the extended forecasting periods of 18 to 24 months, we note for sentiment variables an expected decrease in their predictive abilities (AUROC of 0.69) whereas refinancing variables perform reasonably well with an AUROC of 0.83 and 66% of recessions detected. Surprisingly good predictive qualities for the longer term horizon are associated with the channel capturing the preference for risk. In particular risk-affine investors will appreciate only 12% false positive signals (versus 23% of the other channels).

Based on bivariate specifications, the second submodel continues to yield significantly better results than their underlying univariate time series [Table A13 in the Appendix]. With an average AUROC of 0.98 and 82% of crisis months detected across all possible combinations, the PMI and Real M1 are the preferred indicators for the 6m horizon. In light of their shorter lead-time, channels composed of industrial data and sentiment variables display very strong predictive ability. Lengthening the time horizon to 18 months reveals a substantial increase in

²⁵ While preference for risk and the competitiveness channel yield overall strong results, they are lagging either with regard to the number of recession detected (60% for preference of risk) or a higher number of false alarm (8% for competitiveness)

the number of false positive signals, whereas monetary transmission channels perform better than their univariate peers with 11% false alarm versus 14%.²⁶ A reason for the higher stability of monetary transmission channels could be the inclusion of variables that are not perfectly congruent in their lead-time.

Regarding the third submodel of unstable surges, the analysis reveals for the 6 months horizon an AUROC of 1 for Real M1 with 93% of all recessions months correctly identified [see Table A14 in the Appendix]. Even for the 18m horizons, this augmentation detects 79% of all crises while issuing 15% false positive signals. Both retail sales and MFI loans prove robust for the shorter term horizon with an AUROC of 0.94 (0.90 in the baseline model) and 0.82 respectively (0.81 in the baseline model). The further we move out on the forecasting horizon, the more important becomes the calibration of the lag structure. In light of the results for the 18m horizon, we suggest a coinciding assessment of the cyclical stance (contemporaneous lag) as compared to a lag of 12 months or 24 months for the shorter-term forecasting horizons. Contrary to previous results that render retail sales rather useless for the longer term perspective, the third submodel yields an AUROC of 0.88 and 80% of crisis detected for retail sales over the 24 month horizon.

8. Summary of Results

In order to assess recession probabilities for the Eurozone, this paper applied four different approaches: A univariate benchmark model to identify predictors and their preferred transformations as well as three submodels. For all four approaches out-of-sample analyses are performed as well. To increase robustness and to capture additional dynamics, various forecast horizons next to the benchmark of 12 months were employed to validate the lead-time. In order to measure the predictive power of the indicator variables we rely on three different signaling approaches to come up with robust results: A signaling approach (Kaminsky and Reinhart (1999)), the area under the receiver operating curve (AUROC) and a loss function to model risk-averse and risk-seeking investors (Alessi and Detken (2009)).

The regime change of monetary policy at the zero lower bound is posing challenges to the empirical supremacy of the term spread for signaling recessions. We find that a modified version of the yield curve incorporating the shadow rate by Xia and Wu (2016) removes the downward rigidity of the front-leg and restores part of the informational content of the yield curve. However, regarding the 12m forecasting horizon, the best performing single indicator of the analysis is Real M1 with a lead-time of eleven months before the start of both recessions

²⁶ The average number of crisis detected is similar with 73% for channels versus 72% for univariate indicators.

under consideration. Slightly trailing in performance, the Purchasing Managers Index, the investment grade corporate bond spread and the Terms of Trade yield the highest predictive quality. Considering the 12m transformation of variables instead of their level increases the sensitivity to turning points of the business cycle for those variables that are less leading in nature. Other variables (e.g., Libor-OIS, crude oil) generate good summary statistics but reveal idiosyncratic vulnerabilities that can lead to a higher number of false positive signals.

For risk-averse investors, who are more concerned with not missing a crisis at the expense of a higher number of false positive signals, there is higher relative utility in considering the price of crude oil and Terms of Trade. Results for risk-affine investors suggest a higher relative reliance on variables that are producing fewer false alarms such as HICP inflation and the Eurozone peripheral sovereign bond spread.

On the first submodel, the creation of monetary transmission channels yields the strongest improvements for the categories of industrial data, refinancing variables and preference for risk. As all those three categories are composed of variables prone to idiosyncratic fluctuations, the use of principal component analysis increases the informational value regarding the business cycle. Results for the second submodel suggest bivariate combinations perform significantly better than the univariate specification. In particular, combinations of indicators including Real M1 or the PMI can be considered to be paramount. Bivariate models of monetary transmission channels also outperform their univariate equivalents by far and, in addition, reduce the risk of overfitting compared to bivariate models of single indicators. Considering the deviation from the HP trend in the third submodel achieves significant improvements for indicators in the run-up to the recession of 2008-2009 which can be characterized by signs of overheating. Similarly, monetary policy variables become more sensitive through suggested modification by capturing potential hawkish mistakes.

Regarding different forecasting horizons, sentiment indicators and industrial data improve significantly for shorter time horizons, whereas corporate spreads and the Eurozone peripheral sovereign bond spread underline their leading character vis-à-vis the business cycle given a remarkable performance over longer forecasting horizon. Most of the indicators fail to be useful over the 24m horizon given a high number of false signals. However, indicators of the third submodel reflecting unstable surges provide moderately robust results also for extended forecasting horizons that could serve as complements to short-term forecasts.

References

Alessi, L. / Detken, C. (2009): "Real time early warning indicators for costly asset price boom/bust cycles. A role for global liquidity", ECB Working Paper Series No. 1039.

Bellégo, C. / Ferrara, L. (2009): "Forecasting euro area recessions using time-varying binary response models for financial variables", Document de travail, Banque de France, 259.

Berge, T. J. / Jordà, Ò. (2011): "Evaluating the classification of economic activity into recessions and expansions", *American Economic Journal: Macroeconomics* 3(2), 246-277.

Birdsall, T. G. / Peterson, W. W. (1953): "The theory of signal detectability: Part I. The general theory", *Electronic Defense Group, Technical Report* 13.

Borio, C. / McCauley, R.N. / McGuire, P. / Sushko, V. (2016): "Covered interest parity lost: understanding the cross-currency basis", *BIS quarterly review: international banking and financial market developments* 09/2016, 45-64.

Chauvet, M. / Potter, S. (2005): "Forecasting recessions using the yield curve", *Journal of Forecasting* 24(2), 77-103.

Chen, Z. / Azhar, I. / Lai, H. (2008): "Forecasting the probability of U.S. recessions: a probit and dynamic factor modelling approach", *The Canadian Journal of Economics* 44(2), 651-672.

Dovern, J. / Ziegler, C. (2008): "Predicting growth rates and recessions: Assessing US leading indicators under real-time conditions", *Working Paper*, Kiel, Institute for the World Economy.

Dueker, M. J. (1997): "Strengthening the case for the yield curve as a predictor of U.S. recessions," *St. Louis Fed Review* (Mar), 41-51.

Ergungor, O. E. (2016): "Recession probabilities", *Economic Commentary Federal Reserve Bank of Cleveland* 2016, 1-6.

Estrella, A. / Hardouvelis, G. A. (1991): "The term structure as a predictor of real economic activity", *The Journal of Finance* 46(2), 555-576.

Fornari F. / Lemke, W. (2010): "Predicting recession probabilities with financial variables over multiple horizons," *Working paper series*, European Central Bank, 1255.

Gilchrist, S. / Zakrajšek E.(2012): "Credit spreads and business cycle fluctuations", *American Economic Review* 102(4), 1692-1720.

Haltmaier, J. (2008): "Predicting cycles in economic activity", *Working Paper* 926, Board of Governors of the Federal Reserve System.

Kaminsky, G. / Reinhart, C. (1999): "The twin crises: The causes of banking and balance-of-payments problems", *American Economic Review* 89(3), 473-500.

King, T. B. / Levin, A. T. / Perli, R. (2007): "Financial market perceptions of recession risk", Washington DC: Div. of Research & Statistics and Monetary Affairs, Federal Reserve Board, Finance and economics discussion series; 2007-57.

Krugman, P. R. (1998): "It's baaack: Japan's slump and the return of the liquidity trap", Brookings Papers on Economic Activity 1998, Issue 2, 137-187.

Laubach, T / Williams, J. C. (2015): "Measuring the natural rate of interest redux", Federal Reserve Bank of San Francisco, Working Paper 2015-16.

Levanon, G. / Manini, J.-C. / Ozyildirim, A. / Schaitkin, B. / Tanchua, J. (2011): "Using a leading credit index to predict turning points in the U.S. business cycle", The Conference Board, Economics Program Working Paper Series 11(5).

Liu, W. / Moench, E. (2014): "What predicts U.S. recessions?", Federal Reserve Bank of New York Staff Reports Staff Report No. 691.

Moneta, F. (2005): "Does the yield spread predict recessions in the Euro area?", International Finance 8(2), 263-301.

Peterson, W. W. / Birdsall, T.G. (1953): "The theory of signal detectability: Part I. The general theory," Electronic Defense Group, Technical Report 13. Available from EECS Systems Office, University of Michigan.

Rudebusch, G. D. / Williams, J. C. (2009): "Forecasting recessions: The puzzle of the enduring power of the yield curve", Journal of Business & Economic Statistics 27(4), 492-503.

Summers, L. (2016): "Age of secular stagnation: What it is and what to do about it, the null", Foreign Affairs, 95(2), 2-9.

Wu, J. C. / Xia, F.D.(2016): "Measuring the macroeconomic Impact of monetary policy at the zero lower bound", Journal of Money, Credit, and Banking, 48(2-3), 253-291.

Figure 1: Univariate Benchmark Model – 12m Forecasting Horizon

Figure 1a

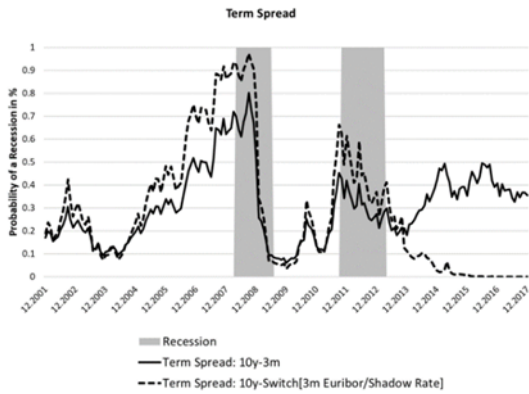


Figure 1b

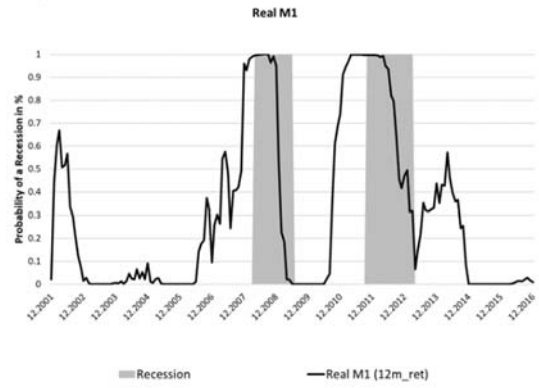


Figure 1c

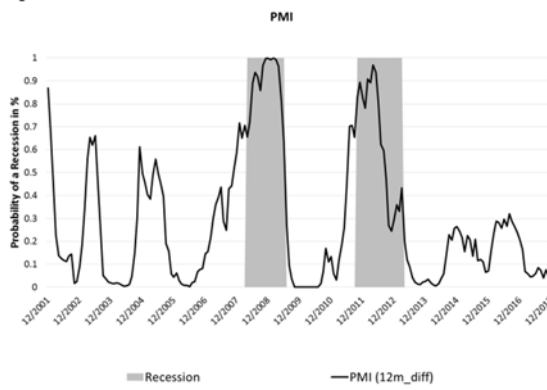


Figure 1d

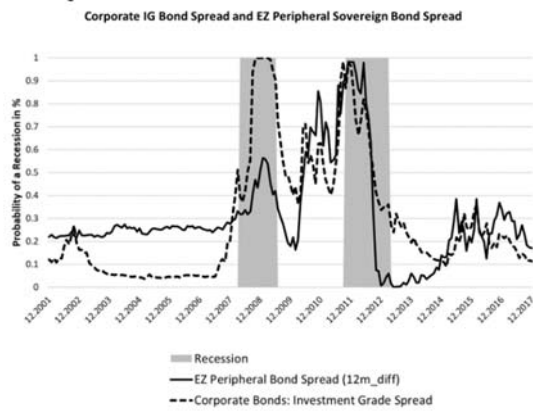


Figure 1e

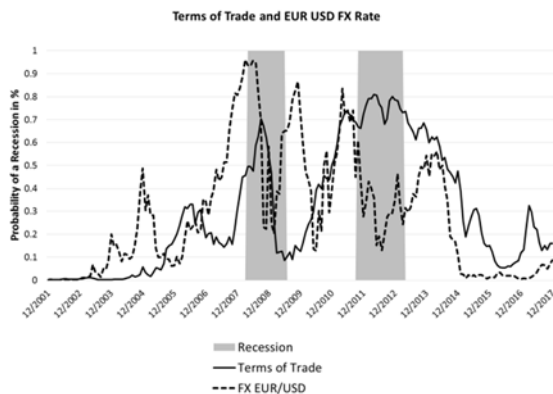


Figure 1f

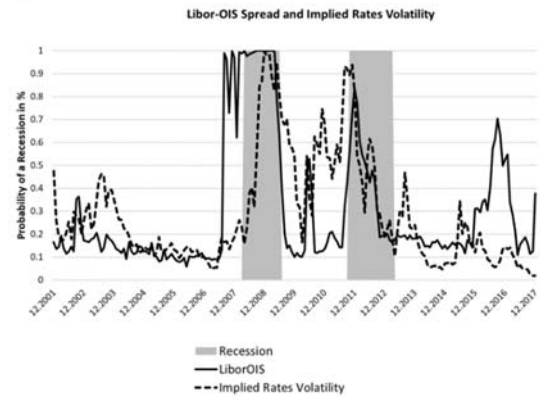


Figure 1g

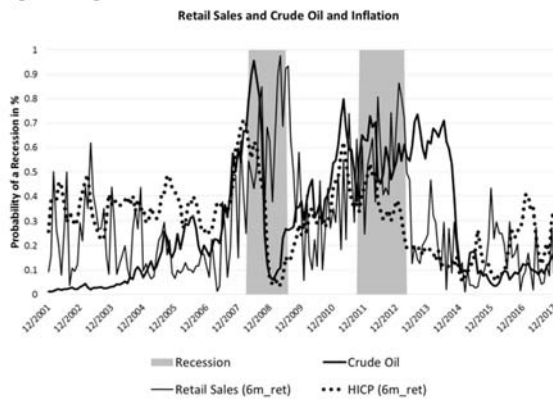


Figure 1h

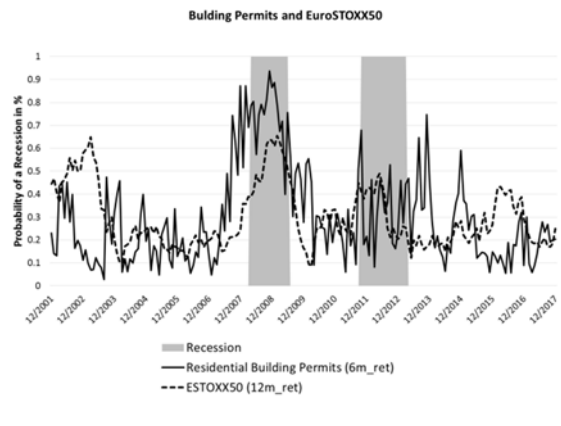


Figure 2: Submodel 1 - Monetary Transmission Channels

Figure 2a

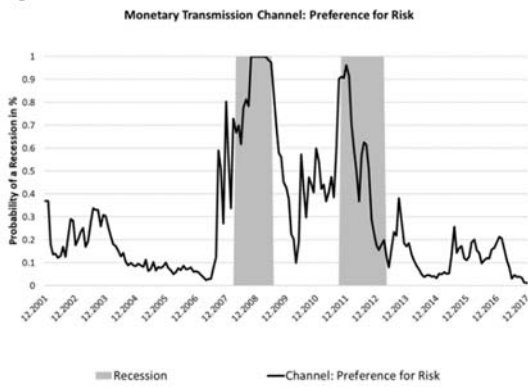


Figure 2b

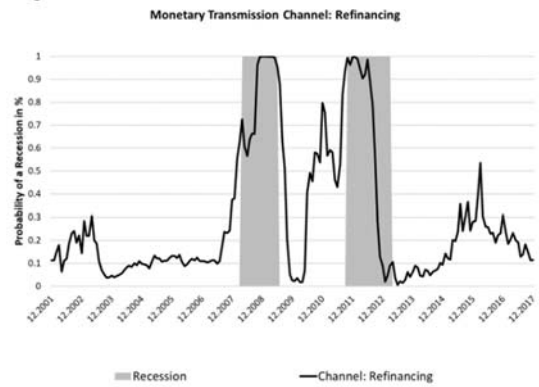


Figure 2c

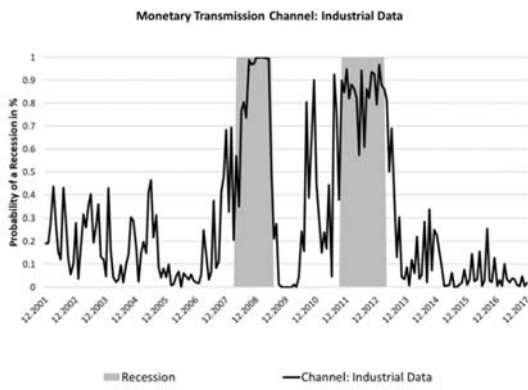


Figure 2d

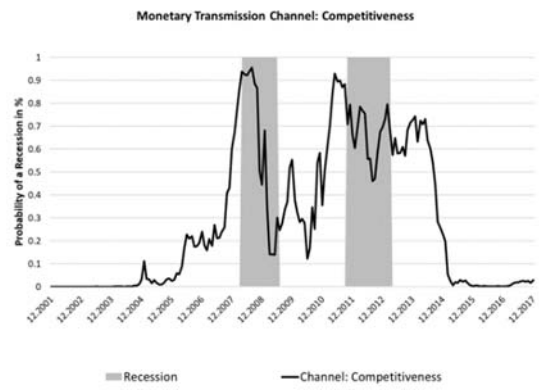


Figure 2e

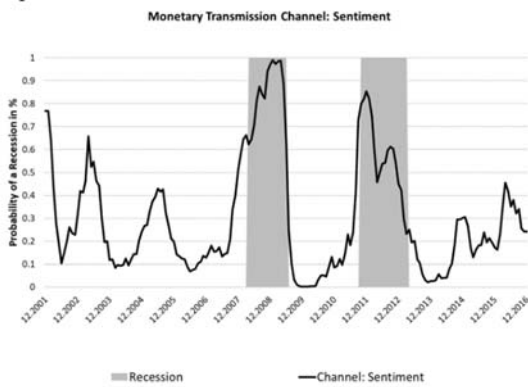


Figure 2f

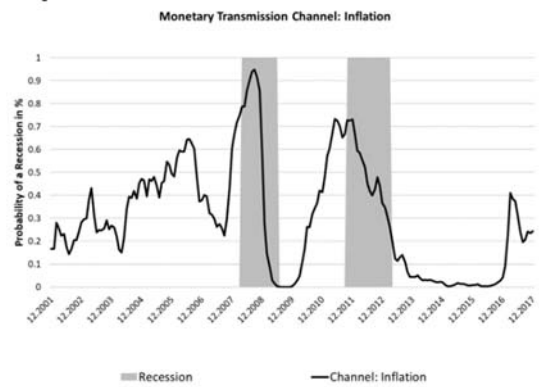


Figure 2g

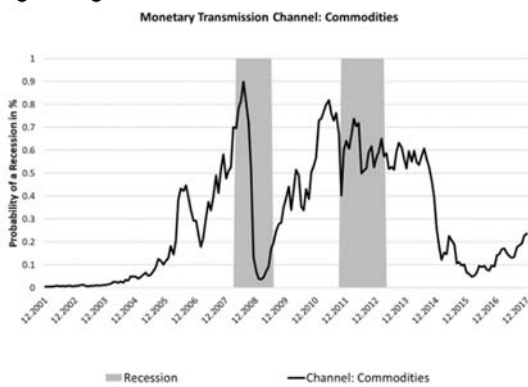


Figure 2h

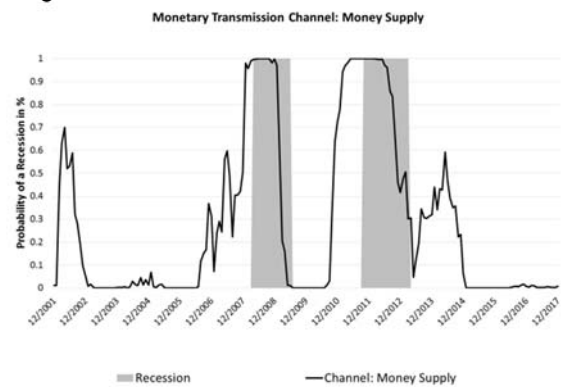


Figure 3: Submodel 2 - Bivariate Specification

Figure 3a

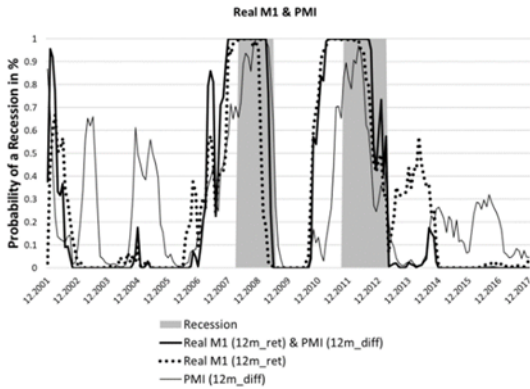


Figure 3b

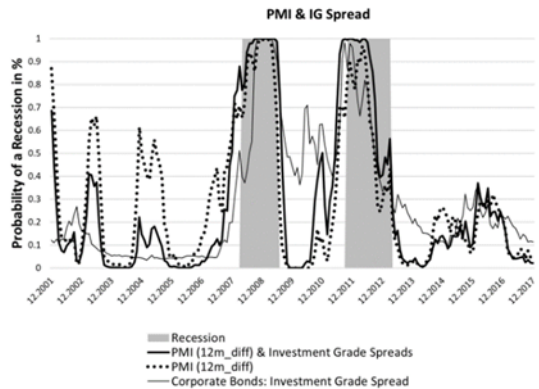


Figure 3c

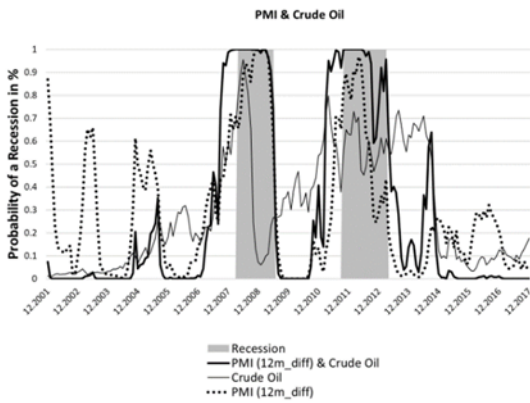


Figure 3d

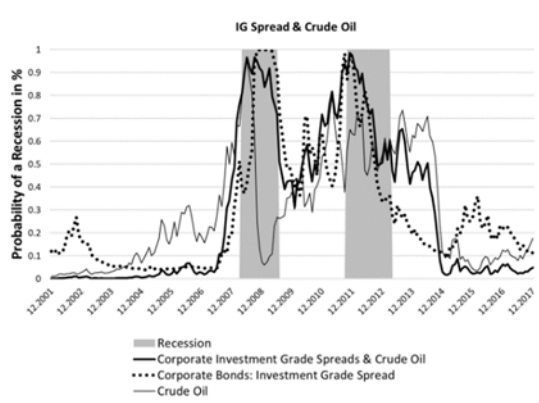


Figure 3e

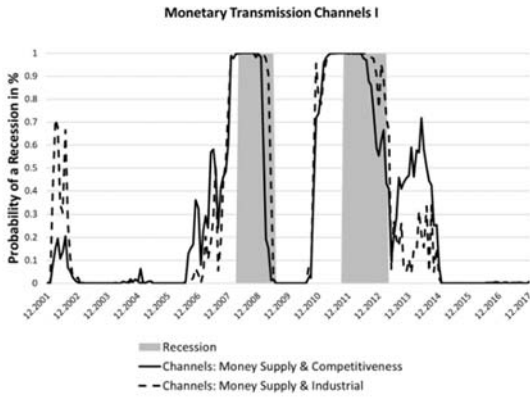


Figure 3f

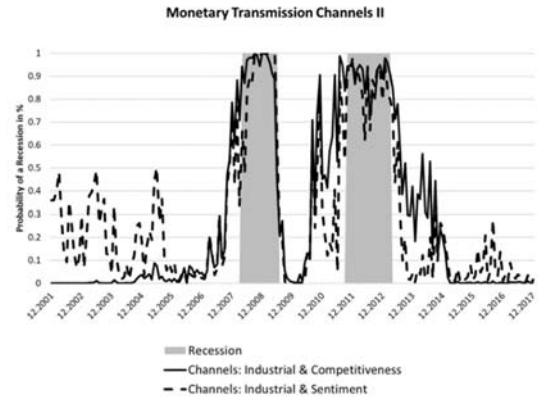


Figure 3g

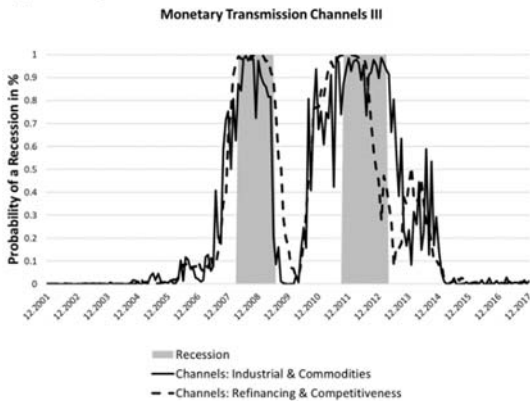


Figure 3h

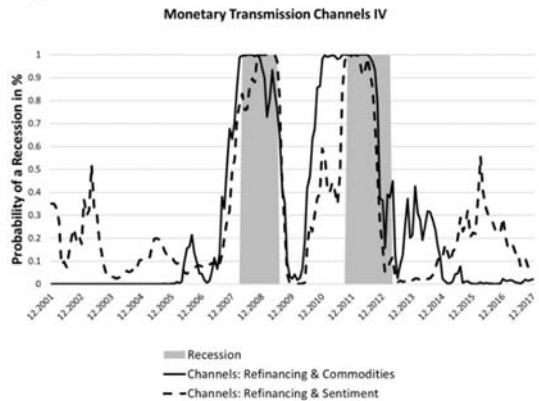


Figure 4: Submodel 3 - Unstable Surges

Figure 4a

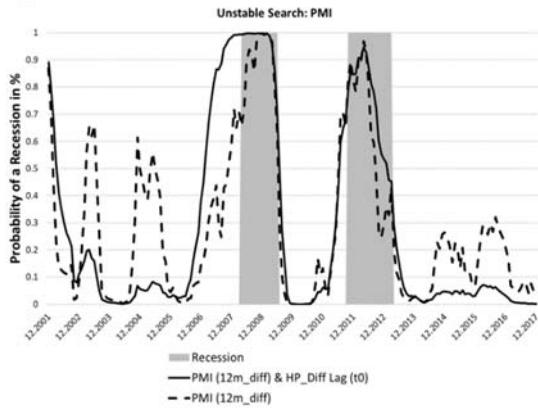


Figure 4b

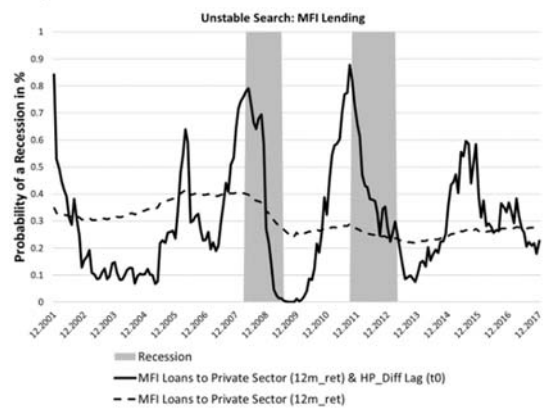


Figure 4c

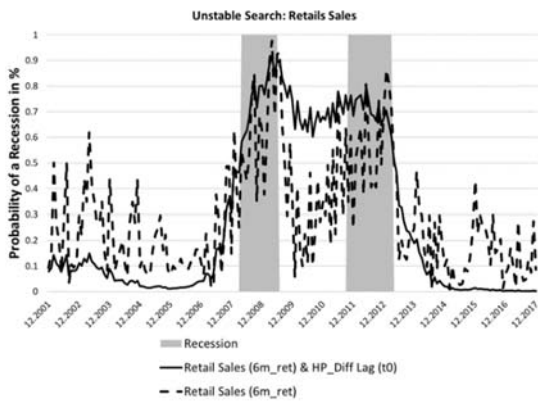


Figure 4d

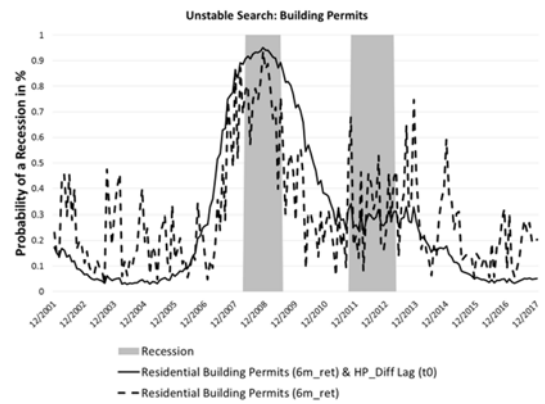


Figure 4e

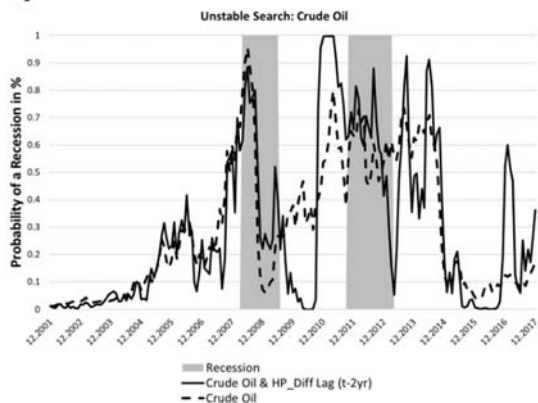


Figure 4f

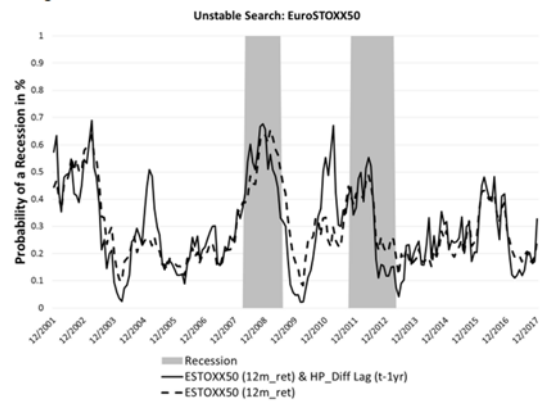


Figure 4g

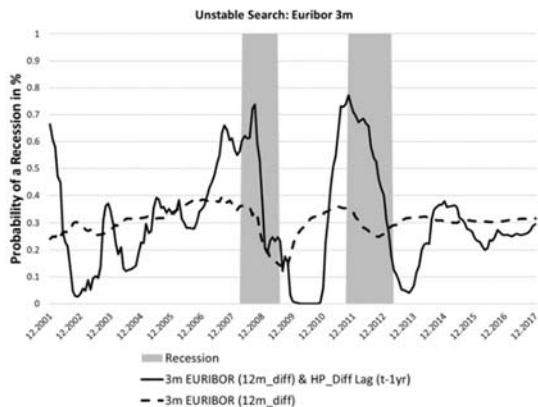


Figure 4h

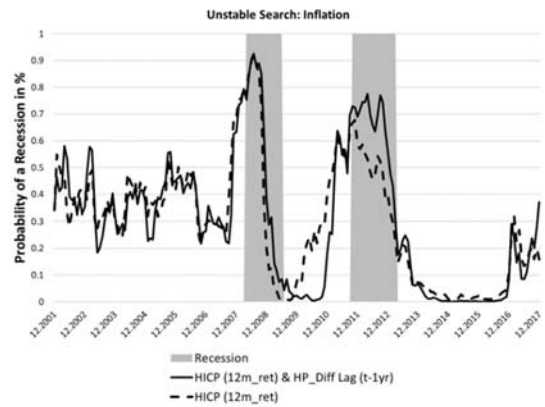


Table 1: List of Variables

Variables	Source	Code	Transformation	Comment
Rates	3m EURIBOR	Haver	N023RI3E@G10	***
	10yr German Government Bond	BBG	GTDEM10Y Govt	***
Term Spread	Term Spread: 10y-3m	BBG / Haver	10yr: GTDEM10Y /3m: N023RI3E@G10	***
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate]	Haver	N023SHDW@G10	***
Money Supply	M1	Haver	S023FM1@G10	**
	Real M1	Haver	Inflation: H025PCXG@G10	**
	M2	Haver	S023FM2@G10	**
	Real M2	Haver	Inflation: H025PCXG@G10	**
	M3	Haver	S023FM3@G10	**
	Real M3	Haver	Inflation: H025PCXG@G10	**
Competitiveness	FX EUR/USD	Haver	N023XUNE@G10	***
	JPM Nominal Broad Effective FX Rate	Haver	N023XJNB@G10	***
	Terms of Trade	Haver	H025PFTT@G10	***
Sentiment	PMI	Haver	M023TG@MKTPMI	***
	Economic Sentiment	Haver	S025VES@G10	***
	Industrial Confidence	Haver	S025VB@G10	***
	Consumer Confidence	Haver	S025VCC@G10	***
	Consumer Economic Situation	Haver	S025VCE@G10	***
	Business Climate	Haver	S025VBC@G10	***
Refinancing	Corporate Bonds: Investment Grade Spread	Barclays	2002	***
	High Yield Spread	ICE	HPC4	***
	EZ Peripheral Bond Spread	BBG	BBG 10yr generic yields of DE/IT/ES/GR/IE/PT	***
	MFI Loans to Private Sector	Haver	S023FCB@G10	**
Risk Aversion	Implied Rates Volatility	BBG	EUNEF10 ICPL / EUSNOF10 / EUSV0F10	***
	VSTOXX	BBG	V2X Index	***
	VIX	BBG	VIX Index	***
	FX Basis EUR/USD	BBG	EUBS1 Index	***
	Implied FX Vol	BBG	EURUSDV1M Index	***
	LiborOIS	BBG	BICLOISS Index	*
Industrial Data	Industrial Production: Industry excl. Constr.	Haver	S025D@G10	**
	Unemployment Rate	Haver	S023ELUR@G10	***
	Manufact. New Orders	Haver	S025TO@G10	**
	Industr. Turnover: Manufacturing	Haver	S025TS@G10	**
	MfG Stocks of Finished Products	Haver	S025TI@G10	***
	Retail Sales	Haver	S025TRSC@G10	**
	New Passenger Cars	Haver	H025CVRT@G10	**
Inflation	HICP	Haver	H023PC@G10	**
	HICP excl. Energy, Food, Alcohol & Tobacco	Haver	H025PCXG@G10	**
	Domestic PPI: Industry excluding Construction	Haver	H025PP@G10	**
Commodities	Crude Oil	BBG	CL1 Comdty	***
	Gold	BBG	XAU Comdty	***
Wealth	ESTOXS0	Haver	N023FKAE@G10	**
	Residential Buidling Permits	Haver	S025HP@G10	**

* Level; ** 6m and 12m change; *** Level, 6m and 12m change

Appendix

Table A1: Univariate Benchmark Model – 12m Forecasting Horizon

12m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued No Signal Issued	A C	B D					L= 0.25	L= 0.75
Rates	3m EURIBOR			64%	80%	33%	0%	0.17	0.50
	3m EURIBOR (6m_diff)			46%	72%	9%	0%	0.23	0.68
	3m EURIBOR (12m_diff)			63%	70%	0%	0%	0.25	0.75
	10yr German Government Bond			53%	70%	0%	0%	0.25	0.75
	10yr German Government Bond (6m_diff)			52%	70%	0%	0%	0.25	0.75
	10yr German Government Bond (12m_diff)			53%	70%	0%	0%	0.25	0.75
Term Spread	Term Spread: 10y-3m			69%	78%	33%	2%	0.19	0.51
	Term Spread: 10y-3m (6m_diff)			53%	70%	0%	0%	0.25	0.75
	Term Spread: 10y-3m (12m_diff)			66%	70%	0%	0%	0.25	0.75
	Term Spread: 10y-Switch(3m Euribor/Shadow Rate)			84%	80%	49%	7%	0.18	0.40
	Term Spread: 10y-Switch(3m Euribor/Shadow Rate) (6m_diff)			57%	70%	0%	0%	0.25	0.75
	Term Spread: 10y-Switch(3m Euribor/Shadow Rate) (12m_diff)			74%	72%	16%	4%	0.24	0.64
Money Supply	M1 (6m_ret)			84%	84%	62%	6%	0.14	0.30
	M1 (12m_ret)			94%	86%	69%	7%	0.13	0.25
	Real M1 (6m_ret)			85%	86%	65%	5%	0.12	0.27
	Real M1 (12m_ret)			95%	88%	73%	5%	0.10	0.22
	M2 (6m_ret)			52%	70%	0%	0%	0.25	0.75
	M2 (12m_ret)			53%	70%	0%	0%	0.25	0.75
	Real M2 (6m_ret)			49%	70%	0%	0%	0.25	0.75
	Real M2 (12m_ret)			50%	70%	0%	0%	0.25	0.75
	M3 (6m_ret)			51%	70%	0%	0%	0.25	0.75
	M3 (12m_ret)			53%	70%	0%	0%	0.25	0.75
	Real M3 (6m_ret)			49%	70%	0%	0%	0.25	0.75
	Real M3 (12m_ret)			51%	70%	0%	0%	0.25	0.75
Competitiveness	FX EUR/USD			84%	78%	49%	10%	0.20	0.41
	FX EUR/USD (6m_ret)			48%	70%	0%	0%	0.25	0.75
	FX EUR/USD (12m_ret)			53%	70%	0%	0%	0.25	0.75
	JPM Nominal Broad Effective FX Rate			67%	70%	16%	6%	0.26	0.64
	JPM Nominal Broad Effective FX Rate (6m_ret)			53%	70%	0%	0%	0.25	0.75
	JPM Nominal Broad Effective FX Rate (12m_ret)			61%	69%	0%	2%	0.26	0.75
	Terms of Trade			85%	78%	60%	13%	0.20	0.33
	Terms of Trade (6m_ret)			63%	70%	0%	0%	0.25	0.75
Terms of Trade (12m_ret)			70%	70%	22%	10%	0.27	0.61	
Sentiment	PMI			69%	79%	40%	4%	0.18	0.46
	PMI (6m_diff)			80%	81%	51%	6%	0.17	0.38
	PMI (12m_diff)			88%	83%	60%	7%	0.15	0.32
	Economic Sentiment			57%	72%	13%	2%	0.23	0.66
	Economic Sentiment (6m_diff)			82%	82%	56%	6%	0.16	0.34
	Economic Sentiment (12m_diff)			76%	81%	47%	5%	0.17	0.41
	Industrial Confidence			48%	70%	0%	0%	0.25	0.75
	Industrial Confidence (6m_diff)			81%	82%	51%	5%	0.16	0.38
	Industrial Confidence (12m_diff)			74%	74%	27%	6%	0.22	0.56
	Consumer Confidence			69%	75%	27%	5%	0.22	0.56
	Consumer Confidence (6m_diff)			77%	81%	51%	6%	0.16	0.38
	Consumer Confidence (12m_diff)			73%	78%	49%	10%	0.20	0.41
	Consumer Economic Situation			75%	83%	55%	5%	0.15	0.35
	Consumer Economic Situation (6m_diff)			76%	80%	47%	6%	0.18	0.41
	Consumer Economic Situation (12m_diff)			79%	80%	51%	8%	0.18	0.39
	Business Climate			48%	70%	0%	0%	0.25	0.75
Business Climate (6m_diff)			81%	82%	51%	5%	0.16	0.38	
Business Climate (12m_diff)			75%	73%	25%	6%	0.23	0.57	
Refinancing	Corporate Bonds: Investment Grade Spread			85%	82%	56%	7%	0.16	0.35
	Corporate Bonds: Investment Grade Spread (6m_diff)			61%	77%	24%	0%	0.19	0.57
	Corporate Bonds: Investment Grade Spread (12m_diff)			78%	82%	44%	1%	0.15	0.42
	High Yield Spread			76%	71%	25%	9%	0.25	0.58
	High Yield Spread (6m_diff)			65%	77%	31%	2%	0.19	0.52
	High Yield Spread (12m_diff)			76%	85%	55%	2%	0.13	0.35
	EZ Peripheral Bond Spread			74%	80%	45%	6%	0.18	0.42
	EZ Peripheral Bond Spread (6m_diff)			77%	71%	11%	2%	0.24	0.67
	EZ Peripheral Bond Spread (12m_diff)			85%	82%	49%	3%	0.15	0.39
	MFI Loans to Private Sector (6m_ret)			52%	70%	0%	0%	0.25	0.75
MFI Loans to Private Sector (12m_ret)			58%	70%	0%	0%	0.25	0.75	
Risk Aversion	Implied Rates Volatility			79%	80%	51%	8%	0.18	0.39
	Implied Rates Volatility (6m_diff)			67%	73%	20%	4%	0.23	0.61
	Implied Rates Volatility (12m_diff)			71%	75%	24%	3%	0.21	0.58
	VSTOXX			66%	69%	13%	6%	0.27	0.67
	VSTOXX (6m_ret)			56%	71%	5%	1%	0.24	0.71
	VSTOXX (12m_ret)			65%	71%	13%	4%	0.25	0.66
	VIX			73%	71%	22%	8%	0.25	0.61
	VIX (6m_ret)			58%	71%	11%	2%	0.24	0.67
	VIX (12m_ret)			70%	79%	40%	4%	0.18	0.46
	FX Basis EUR/USD			78%	75%	38%	9%	0.22	0.49
FX Basis EUR/USD (6m_diff)			53%	70%	0%	0%	0.25	0.75	
FX Basis EUR/USD (12m_diff)			69%	76%	20%	0%	0.20	0.60	
Implied FX Vol			64%	76%	24%	1%	0.20	0.57	
Implied FX Vol (6m_ret)			57%	70%	7%	2%	0.25	0.70	
Implied FX Vol (12m_ret)			64%	71%	15%	5%	0.25	0.65	
LiborOIS			82%	82%	53%	6%	0.16	0.37	
Industrial Data	Industrial Production: Industry excl. Constr. (6m_ret)			65%	73%	15%	2%	0.23	0.64
	Industrial Production: Industry excl. Constr. (12m_ret)			52%	70%	0%	0%	0.25	0.75
	Unemployment Rate			58%	70%	0%	0%	0.25	0.75
	Unemployment Rate (6m_ret)			65%	71%	9%	2%	0.25	0.69
	Unemployment Rate (12m_ret)			56%	70%	0%	0%	0.25	0.75
	Manufact. New Orders (6m_ret)			65%	75%	18%	1%	0.21	0.62
	Manufact. New Orders (12m_ret)			55%	70%	0%	0%	0.25	0.75
	Industr. Turnover: Manufacturing (6m_ret)			54%	72%	9%	1%	0.23	0.68
	Industr. Turnover: Manufacturing (12m_ret)			60%	70%	0%	0%	0.25	0.75
	MfG Stocks of Finished Products			48%	70%	0%	0%	0.25	0.75
	MfG Stocks of Finished Products (6m_diff)			79%	78%	47%	8%	0.19	0.42
	MfG Stocks of Finished Products (12m_diff)			77%	78%	42%	6%	0.19	0.45
	Retail Sales (6m_ret)			83%	80%	45%	6%	0.18	0.42
	Retail Sales (12m_ret)			78%	76%	44%	10%	0.21	0.45
New Passenger Cars (6m_ret)			69%	71%	13%	3%	0.24	0.66	
New Passenger Cars (12m_ret)			78%	77%	45%	10%	0.21	0.43	
Inflation	HICP (6m_ret)			76%	77%	25%	0%	0.19	0.56
	HICP (12m_ret)			82%	83%	53%	3%	0.14	0.36
	HICP excl. Energy, Food, Alcohol & Tobacco (6m_ret)			68%	65%	2%	7%	0.30	0.75
	HICP excl. Energy, Food, Alcohol & Tobacco (12m_ret)			69%	63%	0%	10%	0.32	0.77
	Domestic PPI: Industry excluding Construction (6m_ret)			72%	74%	15%	0%	0.21	0.64
	Domestic PPI: Industry excluding Construction (12m_ret)			80%	76%	51%	13%	0.22	0.40
Commodities	Crude Oil			82%	78%	62%	15%	0.21	0.32
	Crude Oil (6m_diff)			47%	70%	0%	0%	0.25	0.75
	Crude Oil (12m_diff)			52%	70%	0%	0%	0.25	0.75
	Gold			76%	82%	49%	3%	0.15	0.39
	Gold (6m_diff)			58%	70%	2%	1%	0.25	0.74
	Gold (12m_diff)			60%	69%	2%	2%	0.26	0.74
Wealth	ESTOXX50 (6m_ret)			66%	71%	18%	6%	0.25	0.63
	ESTOXX50 (12m_ret)			69%	68%	16%	10%	0.28	0.65
	Residential Building Permits (6m_ret)			76%	77%	40%	6%	0.20	0.47
	Residential Building Permits (12m_ret)			74%	75%	35%	7%	0.22	0.51

“diff” describes the absolute difference between levels; “ret” describes the % change between levels;

Table A2: Submodel 1 - Monetary Transmission Channels

12m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued No Signal Issued	A C	B D					L=0.25	L=0.75
Channel: Money Supply				96%	90%	76%	5%	0.09	0.19
Real M1 (12m_ret)				95%	88%	73%	5%	0.10	0.22
Channel: Competitiveness				89%	80%	71%	16%	0.19	0.26
FX EUR/USD				84%	78%	49%	10%	0.20	0.41
Terms of Trade				85%	78%	60%	13%	0.20	0.33
Channel: Sentiment				80%	83%	56%	6%	0.15	0.34
PMI (12m_diff)				88%	83%	60%	7%	0.15	0.32
Economic Sentiment (6m_diff)				82%	82%	56%	6%	0.16	0.34
Industrial Confidence (6m_diff)				81%	82%	51%	5%	0.16	0.38
Business Climate (6m_diff)				81%	82%	51%	5%	0.16	0.38
Consumer Economic Situation (12m_diff)				79%	80%	51%	8%	0.18	0.39
Consumer Confidence (6m_diff)				77%	81%	51%	6%	0.16	0.38
Channel: Refinancing				88%	87%	69%	5%	0.11	0.24
Corporate Bonds: Investment Grade Spread				85%	82%	56%	7%	0.16	0.35
EZ Peripheral Bond Spread (12m_diff)				85%	82%	49%	3%	0.15	0.39
High Yield Spread (12m_diff)				76%	85%	55%	2%	0.13	0.35
Channel: Preference for Risk				86%	85%	62%	5%	0.13	0.30
LiborOIS				82%	82%	53%	6%	0.16	0.37
Implied Rates Volatility				79%	80%	51%	8%	0.18	0.39
FX Basis EUR/USD				78%	75%	38%	9%	0.22	0.49
Channel: Industrial Data				89%	86%	65%	5%	0.12	0.27
Retail Sales (6m_ret)				83%	80%	45%	6%	0.18	0.42
MFG Stocks of Finished Products (6m_diff)				79%	78%	47%	8%	0.19	0.42
New Passenger Cars (12m_ret)				78%	77%	45%	10%	0.21	0.43
Channel: Inflation				84%	80%	53%	8%	0.18	0.37
HICP (12m_ret)				82%	83%	53%	3%	0.14	0.36
Domestic PPI: Industry excluding Construction (12m_ret)				80%	76%	51%	13%	0.22	0.40
Channel: Commodities				85%	80%	71%	16%	0.19	0.26
Crude Oil				82%	78%	62%	15%	0.21	0.32
Gold				76%	82%	49%	3%	0.15	0.39

Table A3: Submodel 2 - Bivariate Specification

12m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued No Signal Issued	A C	B D					L=0.25	L=0.75
Single Indicators				99%	95%	91%	3%	0.05	0.16
Real M1 (12m_ret) & PMI (12m_diff)				97%	93%	82%	2%	0.06	0.14
Real M1 (12m_ret) & Investment Grade Spreads				96%	91%	78%	4%	0.08	0.17
Real M1 (12m_ret) & Terms of Trade				97%	93%	89%	5%	0.06	0.09
Real M1 (12m_ret) & Crude Oil				96%	91%	76%	2%	0.08	0.18
PMI (12m_diff) & Investment Grade Spreads				93%	87%	64%	3%	0.11	0.28
PMI (12m_diff) & Terms of Trade				97%	91%	78%	3%	0.08	0.17
PMI (12m_diff) & Retail Sales (6m_ret)				90%	85%	71%	9%	0.14	0.24
PMI (12m_diff) & Crude Oil				98%	92%	82%	4%	0.08	0.15
Corporate Investment Grade Spreads & Terms of Trade				90%	86%	78%	11%	0.14	0.19
Corporate Investment Grade Spreads & Retail Sales (6m_ret)				87%	83%	62%	7%	0.15	0.30
Corporate Investment Grade Spreads & Crude Oil				93%	86%	76%	10%	0.13	0.20
Terms of Trade & Retail Sales (6m_ret)				90%	86%	78%	10%	0.13	0.19
Terms of Trade & Crude Oil				86%	79%	65%	15%	0.20	0.30
Retail Sales (6m_ret) & Crude Oil				89%	84%	75%	12%	0.15	0.22
Channels: Money Supply & Industrial				98%	93%	87%	4%	0.06	0.11
Channels: Money Supply & Refinancing				98%	94%	87%	3%	0.06	0.10
Channels: Money Supply & Competitiveness				97%	91%	82%	5%	0.08	0.15
Channels: Money Supply & Sentiment				98%	94%	87%	3%	0.06	0.10
Channels: Money Supply & Commodities				97%	92%	82%	3%	0.07	0.14
Channels: Industrial & Refinancing				93%	88%	73%	6%	0.11	0.22
Channels: Industrial & Competitiveness				96%	90%	82%	7%	0.10	0.15
Channels: Industrial & Sentiment				90%	87%	69%	5%	0.11	0.24
Channels: Industrial & Commodities				96%	91%	87%	7%	0.09	0.11
Channels: Refinancing & Competitiveness				96%	91%	78%	4%	0.08	0.17
Channels: Refinancing & Sentiment				89%	86%	62%	3%	0.12	0.29
Channels: Refinancing & Commodities				97%	92%	82%	3%	0.07	0.14
Channels: Competitiveness & Sentiment				97%	91%	78%	4%	0.08	0.17
Channels: Competitiveness & Commodities				90%	81%	73%	16%	0.19	0.24
Channels: Sentiment & Commodities				98%	91%	84%	6%	0.09	0.14

Table A4: Submodel 3 - Unstable Surges

12m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued No Signal Issued	A C	B D					L=0.25	L=0.75
Money Supply				97%	92%	80%	6%	0.09	0.16
Real M1 & HP_Diff Lag (t0)				97%	92%	84%	5%	0.08	0.13
Real M1 & HP_Diff Lag (t-1yr)				96%	90%	78%	5%	0.09	0.18
Real M1 & HP_Diff Lag (t-2yr)				96%	90%	78%	5%	0.09	0.18
Single Indicator: Real M1 (12m_ret)				95%	88%	73%	5%	0.10	0.22
Equity Markets				68%	70%	18%	7%	0.26	0.63
ESTOXX50 (12m_ret) & HP_Diff Lag (t-1yr)				71%	75%	33%	7%	0.22	0.52
ESTOXX50 (12m_ret) & HP_Diff Lag (t-2yr)				69%	68%	16%	9%	0.27	0.65
ESTOXX50 (12m_ret)				69%	68%	16%	10%	0.28	0.65
Building Permits				89%	76%	45%	11%	0.22	0.44
Residential Building Permits (6m_ret) & HP_Diff Lag (t0)				81%	81%	53%	6%	0.17	0.37
Residential Building Permits (6m_ret) & HP_Diff Lag (t-1yr)				76%	77%	40%	6%	0.20	0.47
Residential Building Permits (6m_ret)				76%	77%	40%	6%	0.20	0.47
Sentiment				94%	91%	82%	6%	0.09	0.15
PMI (12m_diff) & HP_Diff Lag (t0)				90%	81%	62%	11%	0.18	0.31
PMI (12m_diff) & HP_Diff Lag (t-1yr)				90%	82%	64%	10%	0.17	0.30
PMI (12m_diff) & HP_Diff Lag (t-2yr)				88%	83%	60%	7%	0.15	0.32
Single Indicator: PMI (12m_diff)				88%	83%	60%	7%	0.15	0.32
Inflation				82%	85%	55%	2%	0.13	0.35
HICP (12m_ret) & HP_Diff Lag (t0)				84%	85%	62%	5%	0.13	0.30
HICP (12m_ret) & HP_Diff Lag (t-1yr)				84%	82%	56%	6%	0.16	0.34
HICP (12m_ret) & HP_Diff Lag (t-2yr)				82%	83%	53%	3%	0.14	0.36
Single Indicator: HICP (12m_ret)				82%	83%	53%	3%	0.14	0.36
Retail				90%	83%	78%	14%	0.16	0.20
Retail Sales (6m_ret) & HP_Diff Lag (t0)				85%	79%	51%	9%	0.19	0.39
Retail Sales (6m_ret) & HP_Diff Lag (t-1yr)				83%	79%	44%	6%	0.18	0.44
Retail Sales (6m_ret) & HP_Diff Lag (t-2yr)				83%	79%	44%	6%	0.18	0.44
Single Indicator: Retail Sales (6m_ret)				83%	80%	45%	6%	0.18	0.42
Credit Dynamics				81%	78%	47%	9%	0.20	0.42
MFI Loans to Private Sector (12m_ret) & HP_Diff Lag (t0)				70%	70%	4%	1%	0.25	0.75
MFI Loans to Private Sector (12m_ret) & HP_Diff Lag (t-1yr)				62%	72%	9%	1%	0.23	0.68
MFI Loans to Private Sector (12m_ret) & HP_Diff Lag (t-2yr)				58%	70%	0%	0%	0.25	0.75
Single Indicator: MFI Loans to Private Sector (12m_ret)				58%	70%	0%	0%	0.25	0.75
Oil				88%	76%	53%	13%	0.22	0.39
Crude Oil & HP_Diff Lag (t0)				84%	76%	56%	16%	0.23	0.37
Crude Oil & HP_Diff Lag (t-1yr)				90%	85%	71%	9%	0.14	0.24
Crude Oil & HP_Diff Lag (t-2yr)				82%	78%	62%	15%	0.21	0.32
Single Indicator: Crude Oil				82%	78%	62%	15%	0.21	0.32
Central Bank Policy				63%	70%	0%	0%	0.25	0.75
3m EURIBOR (12m_diff) & HP_Diff Lag (t0)				86%	88%	65%	2%	0.10	0.27
3m EURIBOR (12m_diff) & HP_Diff Lag (t-1yr)				57%	75%	16%	0%	0.21	0.63
3m EURIBOR (12m_diff) & HP_Diff Lag (t-2yr)				64%	80%	33%	0%	0.17	0.50
Single Indicator: 3m EURIBOR				64%	80%	33%	0%	0.17	0.50

Table A5: Univariate Benchmark Model - 12m Forecasting Horizon - Out-Of-Sample

Out-Of-Sample			AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse	
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued No Signal Issued	A C	B D					L=0.25	L=0.75
Rates	3m EURIBOR			83%	78%	35%	1%	0.17	0.49
	3m EURIBOR (6m_diff)			43%	69%	4%	0%	0.24	0.72
	3m EURIBOR (12m_diff)			67%	68%	0%	0%	0.25	0.75
	10yr German Government Bond			57%	68%	0%	0%	0.25	0.75
	10yr German Government Bond (6m_diff)			49%	68%	0%	0%	0.25	0.75
10yr German Government Bond (12m_diff)				55%	68%	0%	0%	0.25	0.75
Term Spread	Term Spread: 10y-3m			89%	74%	35%	8%	0.22	0.51
	Term Spread: 10y-3m (6m_diff)			51%	68%	2%	0%	0.25	0.74
	Term Spread: 10y-3m (12m_diff)			66%	68%	0%	0%	0.25	0.75
	Term Spread: 10y-Switch(3m Euribor/Shadow Rate)			89%	75%	27%	2%	0.19	0.55
	Term Spread: 10y-Switch(3m Euribor/Shadow Rate) (6m_diff)			51%	68%	0%	0%	0.25	0.75
	Term Spread: 10y-Switch(3m Euribor/Shadow Rate) (12m_diff)			66%	68%	0%	0%	0.25	0.75
Money Supply	M1 (6m_ret)			77%	84%	55%	3%	0.13	0.35
	M1 (12m_ret)			95%	84%	87%	17%	0.16	0.14
	Real M1 (6m_ret)			78%	82%	51%	3%	0.14	0.37
	Real M1 (12m_ret)			93%	89%	78%	5%	0.09	0.18
	M2 (6m_ret)			83%	72%	20%	3%	0.23	0.61
	M2 (12m_ret)			91%	76%	35%	4%	0.20	0.50
	Real M2 (6m_ret)			81%	71%	18%	3%	0.23	0.62
	Real M2 (12m_ret)			89%	74%	31%	6%	0.22	0.53
	M3 (6m_ret)			76%	71%	15%	2%	0.23	0.65
	M3 (12m_ret)			85%	74%	27%	3%	0.21	0.55
Competitiveness	Real M3 (6m_ret)			75%	71%	13%	2%	0.23	0.66
	Real M3 (12m_ret)			84%	75%	27%	3%	0.20	0.55
	FX EUR/USD			89%	76%	38%	6%	0.20	0.48
	FX EUR/USD (6m_ret)			52%	68%	0%	0%	0.25	0.75
	FX EUR/USD (12m_ret)			52%	68%	0%	0%	0.25	0.75
	JPM Nominal Broad Effective FX Rate			87%	69%	18%	7%	0.26	0.63
	JPM Nominal Broad Effective FX Rate (6m_ret)			53%	68%	0%	0%	0.25	0.75
	JPM Nominal Broad Effective FX Rate (12m_ret)			51%	68%	0%	0%	0.25	0.75
	Terms of Trade			86%	74%	26%	28%	0.27	0.35
	Terms of Trade (6m_ret)			50%	68%	0%	0%	0.25	0.75
Terms of Trade (12m_ret)			53%	68%	0%	0%	0.25	0.75	
Sentiment	PMI			69%	74%	20%	1%	0.21	0.60
	PMI (6m_diff)			87%	78%	38%	3%	0.17	0.47
	PMI (12m_diff)			92%	82%	55%	4%	0.15	0.35
	Economic Sentiment			50%	68%	0%	0%	0.25	0.75
	Economic Sentiment (6m_diff)			91%	82%	51%	3%	0.14	0.37
	Economic Sentiment (12m_diff)			83%	75%	33%	4%	0.20	0.52
	Industrial Confidence			44%	68%	0%	0%	0.25	0.75
	Industrial Confidence (6m_diff)			92%	79%	47%	5%	0.17	0.41
	Industrial Confidence (12m_diff)			83%	71%	20%	4%	0.23	0.61
	Consumer Confidence			54%	68%	0%	0%	0.25	0.75
	Consumer Confidence (6m_diff)			80%	78%	44%	5%	0.18	0.44
	Consumer Confidence (12m_diff)			76%	74%	24%	3%	0.21	0.58
	Consumer Economic Situation			65%	75%	25%	0%	0.19	0.56
	Consumer Economic Situation (6m_diff)			82%	76%	40%	6%	0.20	0.47
	Consumer Economic Situation (12m_diff)			80%	79%	42%	3%	0.17	0.44
Refinancing	Business Climate			44%	68%	0%	0%	0.25	0.75
	Business Climate (6m_diff)			90%	80%	47%	4%	0.16	0.41
	Business Climate (12m_diff)			83%	71%	18%	4%	0.24	0.62
	Corporate Bonds: Investment Grade Spread			79%	77%	36%	3%	0.19	0.49
	Corporate Bonds: Investment Grade Spread (6m_diff)			87%	78%	35%	1%	0.17	0.49
	Corporate Bonds: Investment Grade Spread (12m_diff)			94%	84%	53%	2%	0.13	0.36
	High Yield Spread			70%	72%	16%	1%	0.22	0.63
	High Yield Spread (6m_diff)			86%	76%	31%	3%	0.19	0.52
	High Yield Spread (12m_diff)			95%	84%	55%	2%	0.13	0.35
	EZ Peripheral Bond Spread			76%	74%	53%	16%	0.24	0.39
	EZ Peripheral Bond Spread (6m_diff)			81%	74%	29%	4%	0.21	0.54
	EZ Peripheral Bond Spread (12m_diff)			84%	82%	55%	4%	0.15	0.35
	MFI Loans to Private Sector (6m_ret)			66%	68%	0%	0%	0.25	0.75
	MFI Loans to Private Sector (12m_ret)			76%	68%	2%	3%	0.27	0.74
	Risk Aversion	Implied Rates Volatility			64%	75%	24%	1%	0.20
Implied Rates Volatility (6m_diff)				87%	73%	36%	10%	0.23	0.50
Implied Rates Volatility (12m_diff)				84%	73%	27%	5%	0.22	0.56
VSTOXX				64%	68%	2%	1%	0.25	0.74
VSTOXX (6m_ret)				71%	68%	7%	3%	0.26	0.70
VSTOXX (12m_ret)				81%	68%	16%	7%	0.26	0.64
VIX				75%	72%	16%	2%	0.22	0.62
VIX (6m_ret)				76%	71%	20%	5%	0.24	0.61
VIX (12m_ret)				92%	78%	44%	6%	0.19	0.44
FX Basis EUR/USD				82%	76%	40%	6%	0.20	0.47
FX Basis EUR/USD (6m_diff)				82%	70%	7%	0%	0.23	0.70
FX Basis EUR/USD (12m_diff)				89%	76%	47%	10%	0.21	0.42
Implied FX Vol				54%	71%	11%	0%	0.22	0.67
Implied FX Vol (6m_ret)				72%	69%	20%	7%	0.25	0.62
Implied FX Vol (12m_ret)				82%	71%	31%	10%	0.24	0.54
LiborOIS			88%	82%	44%	0%	0.14	0.42	
Industrial Data	Industrial Production: Industry excl. Constr. (6m_ret)			68%	71%	13%	2%	0.23	0.66
	Industrial Production: Industry excl. Constr. (12m_ret)			54%	69%	5%	0%	0.24	0.71
	Unemployment Rate			89%	78%	36%	3%	0.18	0.48
	Unemployment Rate (6m_ret)			47%	68%	0%	0%	0.25	0.75
	Unemployment Rate (12m_ret)			66%	68%	0%	0%	0.25	0.75
	Manufact. New Orders (6m_ret)			72%	72%	16%	1%	0.22	0.63
	Manufact. New Orders (12m_ret)			60%	69%	9%	3%	0.25	0.69
	Industr. Turnover: Manufacturing (6m_ret)			64%	70%	11%	2%	0.24	0.67
	Industr. Turnover: Manufacturing (12m_ret)			53%	68%	0%	0%	0.25	0.75
	MFG Stocks of Finished Products			54%	70%	7%	0%	0.23	0.70
	MFG Stocks of Finished Products (6m_diff)			93%	77%	47%	9%	0.20	0.42
	MFG Stocks of Finished Products (12m_diff)			87%	78%	42%	4%	0.18	0.45
	Retail Sales (6m_ret)			76%	73%	22%	3%	0.22	0.59
	Retail Sales (12m_ret)			67%	67%	7%	4%	0.26	0.71
	New Passenger Cars (6m_ret)			63%	68%	0%	0%	0.25	0.75
New Passenger Cars (12m_ret)			69%	72%	18%	3%	0.22	0.62	
Inflation	HICP (6m_ret)			64%	68%	0%	0%	0.25	0.75
	HICP (12m_ret)			61%	69%	5%	0%	0.24	0.71
	HICP excl. Energy, Food, Alcohol & Tobacco (6m_ret)			64%	68%	0%	0%	0.25	0.75
	HICP excl. Energy, Food, Alcohol & Tobacco (12m_ret)			68%	68%	0%	0%	0.25	0.75
	Domestic PPI: Industry excluding Construction (6m_ret)			61%	68%	0%	0%	0.25	0.75
Domestic PPI: Industry excluding Construction (12m_ret)			66%	68%	2%	0%	0.25	0.74	
Commodities	Crude Oil			81%	78%	71%	18%	0.21	0.26
	Crude Oil (6m_diff)			47%	68%	0%	0%	0.25	0.75
	Crude Oil (12m_diff)			53%	68%	0%	0%	0.25	0.75
	Gold			81%	56%	53%	42%	0.43	0.46
	Gold (6m_diff)			49%	68%	0%	0%	0.25	0.75
Wealth	Gold (12m_diff)			57%	68%	0%	0%	0.25	0.75
	ESTOXX50 (6m_ret)			77%	69%	16%	5%	0.25	0.64
	ESTOXX50 (12m_ret)			69%	70%	9%	1%	0.23	0.68
	Residential Building Permits (6m_ret)			93%	75%	35%	5%	0.20	0.50
	Residential Building Permits (12m_ret)			88%	74%	31%	5%	0.21	0.53

Table A6: Submodel 1 - Monetary Transmission Channels - Out-Of-Sample

Out-Of-Sample				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive rate vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued No Signal Issued	A C	B D					L = 0.25	L = 0.75
Channel: Money Supply				94%	89%	80%	6%	0.10	0.17
Real M1 (12m_ret)				93%	89%	78%	5%	0.09	0.18
Channel: Competitiveness				91%	80%	80%	20%	0.20	0.20
FX EUR/USD				89%	76%	38%	6%	0.20	0.48
Terms of Trade				86%	74%	76%	28%	0.27	0.25
Channel: Sentiment				85%	78%	40%	4%	0.18	0.46
PMI (12m_diff)				92%	82%	55%	4%	0.15	0.35
Economic Sentiment (6m_diff)				91%	82%	51%	3%	0.14	0.37
Industrial Confidence (6m_diff)				92%	79%	47%	5%	0.17	0.41
Business Climate (6m_diff)				90%	80%	47%	4%	0.16	0.41
Consumer Economic Situation (12m_diff)				80%	79%	42%	3%	0.17	0.44
Consumer Confidence (6m_diff)				80%	78%	44%	5%	0.18	0.44
Channel: Refinancing				88%	84%	56%	3%	0.14	0.34
Corporate Bonds: Investment Grade Spread				79%	77%	36%	3%	0.19	0.49
EZ Peripheral Bond Spread (12m_diff)				84%	82%	55%	4%	0.15	0.35
High Yield Spread (12m_diff)				95%	84%	55%	2%	0.13	0.35
Channel: Preference for Risk				80%	76%	31%	2%	0.19	0.52
LiborOIS				88%	82%	44%	0%	0.14	0.42
Implied Rates Volatility				64%	75%	24%	1%	0.20	0.57
FX Basis EUR/USD				82%	76%	40%	6%	0.20	0.47
Channel: Industrial Data				86%	85%	62%	3%	0.12	0.30
Retail Sales (6m_ret)				76%	73%	22%	3%	0.22	0.59
MFG Stocks of Finished Products (6m_diff)				93%	77%	47%	9%	0.20	0.42
New Passenger Cars (12m_ret)				69%	72%	18%	3%	0.22	0.62
Channel: Inflation				68%	71%	11%	0%	0.22	0.67
HICP (12m_ret)				61%	69%	5%	0%	0.24	0.71
Domestic PPI: Industry excluding Construction (12m_ret)				66%	68%	2%	0%	0.25	0.74
Channel: Commodities				84%	79%	76%	19%	0.20	0.23
Crude Oil				81%	78%	71%	18%	0.21	0.26
Gold				81%	56%	53%	42%	0.43	0.46

Table A7: Submodel 2 - Bivariate Specification - Out-Of-Sample

Out-Of-Sample				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse	
Transmission Channel	Classification	Recession	No Recession	True positive rate vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *		
	Signal Issued No Signal Issued	A C	B D					L = 0.25	L = 0.75	
Single Indicators	Real M1 (12m_ret) & PMI (12m_diff)			99%	92%	78%	2%	0.07	0.17	
	Real M1 (12m_ret) & Investment Grade Spreads			97%	92%	87%	6%	0.08	0.11	
	Real M1 (12m_ret) & Terms of Trade			96%	84%	93%	20%	0.17	0.10	
	Real M1 (12m_ret) & Retail Sales (6m_ret)			97%	92%	89%	7%	0.08	0.10	
	Real M1 (12m_ret) & Crude Oil			96%	85%	91%	17%	0.15	0.11	
	PMI (12m_diff) & Investment Grade Spreads			93%	85%	56%	2%	0.13	0.33	
	PMI (12m_diff) & Terms of Trade			100%	82%	96%	24%	0.19	0.09	
	PMI (12m_diff) & Retail Sales (6m_ret)			93%	83%	83%	3%	0.14	0.36	
	PMI (12m_diff) & Crude Oil			99%	86%	95%	17%	0.14	0.08	
	Corporate Investment Grade Spreads & Terms of Trade			89%	80%	82%	21%	0.21	0.19	
	Corporate Investment Grade Spreads & Retail Sales (6m_ret)			79%	80%	36%	2%	0.17	0.48	
	Corporate Investment Grade Spreads & Crude Oil			93%	81%	89%	22%	0.19	0.14	
	Terms of Trade & Retail Sales (6m_ret)			90%	81%	82%	19%	0.19	0.18	
	Terms of Trade & Crude Oil			86%	77%	76%	23%	0.23	0.23	
	Retail Sales (6m_ret) & Crude Oil			87%	80%	75%	18%	0.20	0.24	
	Channels	Channels: Money Supply & Industrial			97%	94%	91%	4%	0.05	0.08
		Channels: Money Supply & Refinancing			98%	92%	80%	2%	0.07	0.16
Channels: Money Supply & Competitiveness				97%	87%	91%	15%	0.14	0.11	
Channels: Money Supply & Sentiment				97%	92%	80%	2%	0.07	0.16	
Channels: Money Supply & Commodities				96%	88%	89%	13%	0.12	0.11	
Channels: Industrial & Refinancing				88%	88%	67%	2%	0.10	0.25	
Channels: Industrial & Competitiveness				87%	87%	67%	4%	0.11	0.26	
Channels: Industrial & Sentiment				86%	87%	64%	2%	0.11	0.28	
Channels: Industrial & Commodities				99%	90%	91%	11%	0.11	0.10	
Channels: Refinancing & Competitiveness				88%	84%	55%	3%	0.14	0.35	
Channels: Refinancing & Sentiment				86%	85%	55%	2%	0.13	0.34	
Channels: Refinancing & Commodities				98%	91%	82%	6%	0.09	0.15	
Channels: Competitiveness & Sentiment				84%	86%	55%	0%	0.11	0.34	
Channels: Competitiveness & Commodities			95%	77%	84%	25%	0.23	0.19		
Channels: Sentiment & Commodities			99%	91%	85%	7%	0.09	0.13		

Table A8: Submodel 3 - Unstable Surges - Out-Of-Sample

Out-Of-Sample				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive rate vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued No Signal Issued	A C	B D					L = 0.25	L = 0.75
Money Supply	Real M1 & HP_Diff Lag (t0)			97%	89%	89%	11%	0.11	0.11
	Real M1 & HP_Diff Lag (t-1yr)			97%	92%	87%	6%	0.07	0.11
	Real M1 & HP_Diff Lag (t-2yr)			94%	90%	75%	4%	0.09	0.20
Equity Markets	Single Indicator: Real M1 (12m_ret)			93%	89%	78%	5%	0.09	0.18
	ESTOXX50 (12m_ret) & HP_Diff Lag (t0)			67%	72%	13%	2%	0.23	0.66
	ESTOXX50 (12m_ret) & HP_Diff Lag (t-1yr)			73%	72%	15%	3%	0.24	0.65
	ESTOXX50 (12m_ret) & HP_Diff Lag (t-2yr)			72%	73%	16%	2%	0.23	0.63
Building Permits	ESTOXX50 (12m_ret)			69%	70%	9%	1%	0.23	0.68
	Residential Building Permits (6m_ret) & HP_Diff Lag (t0)			96%	77%	38%	6%	0.20	0.48
	Residential Building Permits (6m_ret) & HP_Diff Lag (t-1yr)			95%	81%	47%	4%	0.16	0.41
	Residential Building Permits (6m_ret) & HP_Diff Lag (t-2yr)			92%	78%	36%	4%	0.19	0.49
Sentiment	Residential Building Permits (6m_ret)			93%	75%	35%	5%	0.20	0.50
	PMI (12m_diff) & HP_Diff Lag (t0)			100%	86%	56%	1%	0.12	0.33
	PMI (12m_diff) & HP_Diff Lag (t-1yr)			92%	83%	53%	4%	0.15	0.36
	PMI (12m_diff) & HP_Diff Lag (t-2yr)			92%	83%	55%	4%	0.14	0.35
Inflation	Single Indicator: PMI (12m_diff)			92%	82%	55%	4%	0.15	0.35
	HICP (12m_ret) & HP_Diff Lag (t0)			64%	51%	20%	36%	0.47	0.69
	HICP (12m_ret) & HP_Diff Lag (t-1yr)			74%	83%	49%	2%	0.15	0.39
	HICP (12m_ret) & HP_Diff Lag (t-2yr)			71%	79%	33%	1%	0.17	0.51
Retail	Single Indicator: HICP (12m_ret)			61%	69%	5%	0%	0.24	0.71
	Retail Sales (6m_ret) & HP_Diff Lag (t0)			84%	85%	71%	10%	0.14	0.24
	Retail Sales (6m_ret) & HP_Diff Lag (t-1yr)			78%	78%	36%	3%	0.18	0.49
	Retail Sales (6m_ret) & HP_Diff Lag (t-2yr)			76%	75%	24%	3%	0.21	0.58
Credit Dynamics	Single Indicator: Retail Sales (6m_ret)			76%	73%	22%	3%	0.22	0.59
	MFI Loans to Private Sector (12m_ret) & HP_Diff Lag (t0)			80%	75%	24%	3%	0.21	0.58
	MFI Loans to Private Sector (12m_ret) & HP_Diff Lag (t-1yr)			93%	76%	33%	6%	0.21	0.52
	MFI Loans to Private Sector (12m_ret) & HP_Diff Lag (t-2yr)			82%	78%	29%	1%	0.18	0.53
Oil	Single Indicator: MFI Loans to Private Sector (12m_ret)			76%	66%	2%	3%	0.27	0.74
	Crude Oil & HP_Diff Lag (t0)			89%	76%	78%	25%	0.25	0.23
	Crude Oil & HP_Diff Lag (t-1yr)			89%	78%	73%	19%	0.21	0.25
	Crude Oil & HP_Diff Lag (t-2yr)			91%	80%	78%	20%	0.20	0.21
Central Bank Policy	Single Indicator: Crude Oil			81%	78%	71%	18%	0.21	0.26
	3m EURIBOR (12m_diff) & HP_Diff Lag (t0)			74%	70%	0%	0%	0.25	0.75
	3m EURIBOR (12m_diff) & HP_Diff Lag (t-1yr)			91%	87%	65%	4%	0.12	0.27
	3m EURIBOR (12m_diff) & HP_Diff Lag (t-2yr)			66%	70%	0%	0%	0.25	0.75
Single Indicator: 3m EURIBOR			83%	78%	35%	1%	0.17	0.49	

Table A9: The Univariate Benchmark Model over the 6m Forecasting Horizon

6m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued No Signal Issued	A C	B D					L=0.25	L=0.75
Rates	3m EURIBOR			62%	77%	0%	0%	0.25	0.75
	3m EURIBOR (6m_diff)			58%	80%	14%	1%	0.22	0.65
	3m EURIBOR (12m_diff)			47%	77%	0%	0%	0.25	0.75
	10yr German Government Bond			50%	77%	0%	0%	0.25	0.75
	10yr German Government Bond (6m_diff)			64%	79%	7%	0%	0.23	0.70
	10yr German Government Bond (12m_diff)			62%	77%	0%	0%	0.25	0.75
Term Spread	Term Spread: 10y-3m			70%	83%	33%	1%	0.18	0.51
	Term Spread: 10y-3m (6m_diff)			52%	77%	0%	0%	0.25	0.75
	Term Spread: 10y-3m (12m_diff)			60%	77%	0%	0%	0.25	0.75
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate]			85%	79%	37%	9%	0.22	0.49
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate] (6m_diff)			58%	77%	0%	0%	0.25	0.75
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate] (12m_diff)			69%	77%	0%	0%	0.25	0.75
Money Supply	M1 (6m_ret)			80%	84%	44%	4%	0.17	0.43
	M1 (12m_ret)			93%	90%	70%	3%	0.10	0.24
	Real M1 (6m_ret)			80%	84%	44%	4%	0.17	0.43
	Real M1 (12m_ret)			94%	91%	70%	2%	0.09	0.23
	M2 (6m_ret)			51%	77%	0%	0%	0.25	0.75
	M2 (12m_ret)			52%	77%	0%	0%	0.25	0.75
	Real M2 (6m_ret)			52%	77%	0%	0%	0.25	0.75
	Real M2 (12m_ret)			49%	77%	0%	0%	0.25	0.75
	M3 (6m_ret)			49%	77%	0%	0%	0.25	0.75
	M3 (12m_ret)			52%	77%	0%	0%	0.25	0.75
	Real M3 (6m_ret)			53%	77%	0%	0%	0.25	0.75
	Real M3 (12m_ret)			50%	77%	0%	0%	0.25	0.75
Competitiveness	FX EUR/USD			81%	81%	40%	6%	0.20	0.47
	FX EUR/USD (6m_ret)			55%	77%	0%	0%	0.25	0.75
	FX EUR/USD (12m_ret)			54%	77%	0%	0%	0.25	0.75
	JPM Nominal Broad Effective FX Rate			66%	75%	0%	2%	0.27	0.76
	JPM Nominal Broad Effective FX Rate (6m_ret)			54%	77%	0%	0%	0.25	0.75
	JPM Nominal Broad Effective FX Rate (12m_ret)			56%	77%	0%	0%	0.25	0.75
	Terms of Trade			88%	83%	63%	10%	0.17	0.31
	Terms of Trade (6m_ret)			61%	77%	0%	0%	0.25	0.75
	Terms of Trade (12m_ret)			69%	77%	0%	0%	0.25	0.75
	PMI			86%	85%	56%	6%	0.16	0.35
Sentiment	PMI (6m_diff)			84%	86%	47%	3%	0.15	0.41
	PMI (12m_diff)			95%	90%	74%	5%	0.10	0.20
	Economic Sentiment			75%	81%	28%	3%	0.20	0.55
	Economic Sentiment (6m_diff)			94%	90%	70%	3%	0.10	0.24
	Economic Sentiment (12m_diff)			90%	88%	60%	4%	0.13	0.31
	Industrial Confidence			64%	79%	16%	2%	0.22	0.63
	Industrial Confidence (6m_diff)			92%	89%	65%	4%	0.12	0.27
	Industrial Confidence (12m_diff)			88%	85%	51%	5%	0.16	0.38
	Consumer Confidence			83%	83%	42%	5%	0.18	0.45
	Consumer Confidence (6m_diff)			89%	88%	63%	5%	0.13	0.29
	Consumer Confidence (12m_diff)			88%	82%	51%	8%	0.18	0.39
	Consumer Economic Situation			91%	90%	70%	4%	0.11	0.24
	Consumer Economic Situation (6m_diff)			86%	86%	53%	5%	0.15	0.36
	Consumer Economic Situation (12m_diff)			89%	87%	65%	6%	0.13	0.28
	Business Climate			65%	78%	14%	3%	0.24	0.65
	Business Climate (6m_diff)			93%	89%	65%	4%	0.12	0.27
	Business Climate (12m_diff)			89%	84%	47%	5%	0.17	0.41
	Refinancing	Corporate Bonds: Investment Grade Spread			91%	85%	51%	5%	0.16
Corporate Bonds: Investment Grade Spread (6m_diff)				61%	82%	23%	0%	0.19	0.58
Corporate Bonds: Investment Grade Spread (12m_diff)				77%	85%	35%	0%	0.16	0.49
High Yield Spread				87%	79%	33%	7%	0.22	0.52
High Yield Spread (6m_diff)				67%	82%	28%	1%	0.19	0.54
High Yield Spread (12m_diff)				80%	90%	58%	1%	0.11	0.32
EZ Peripheral Bond Spread				77%	87%	47%	1%	0.14	0.40
EZ Peripheral Bond Spread (6m_diff)				74%	80%	12%	0%	0.22	0.66
EZ Peripheral Bond Spread (12m_diff)				83%	82%	30%	3%	0.20	0.53
MFI Loans to Private Sector (6m_ret)				54%	77%	0%	0%	0.25	0.75
MFI Loans to Private Sector (12m_ret)				54%	77%	0%	0%	0.25	0.75
Risk Aversion		Implied Rates Volatility			83%	81%	35%	6%	0.20
	Implied Rates Volatility (6m_diff)			63%	80%	12%	0%	0.22	0.66
	Implied Rates Volatility (12m_diff)			72%	81%	23%	1%	0.20	0.58
	VSTOXX			71%	75%	12%	6%	0.26	0.68
	VSTOXX (6m_ret)			57%	77%	2%	1%	0.25	0.73
	VSTOXX (12m_ret)			66%	78%	9%	2%	0.24	0.69
	VIX			77%	79%	23%	5%	0.23	0.59
	VIX (6m_ret)			58%	79%	9%	1%	0.23	0.68
	VIX (12m_ret)			70%	81%	26%	2%	0.20	0.56
	FX Basis EUR/USD			80%	82%	40%	6%	0.19	0.47
	FX Basis EUR/USD (6m_diff)			55%	77%	0%	0%	0.25	0.75
	FX Basis EUR/USD (12m_diff)			70%	79%	9%	0%	0.23	0.68
Industrial Data	Implied FX Vol (6m_ret)			71%	81%	23%	1%	0.20	0.58
	Implied FX Vol (12m_ret)			60%	78%	9%	2%	0.24	0.69
	LiborOIS			68%	78%	14%	3%	0.24	0.65
	Industrial Production: Industry excl. Constr. (6m_ret)			79%	80%	21%	2%	0.21	0.60
	Industrial Production: Industry excl. Constr. (12m_ret)			67%	77%	12%	3%	0.25	0.67
	Unemployment Rate			54%	77%	0%	0%	0.25	0.75
	Unemployment Rate (6m_ret)			79%	79%	16%	3%	0.23	0.63
	Unemployment Rate (12m_ret)			67%	74%	5%	5%	0.27	0.73
	Manufact. New Orders (6m_ret)			80%	84%	35%	1%	0.17	0.49
	Manufact. New Orders (12m_ret)			70%	78%	14%	3%	0.24	0.65
	Industr. Turnover: Manufacturing (6m_ret)			66%	79%	14%	1%	0.23	0.65
	Industr. Turnover: Manufacturing (12m_ret)			52%	77%	0%	0%	0.25	0.75
	MFG Stocks of Finished Products			63%	80%	14%	0%	0.22	0.65
	MFG Stocks of Finished Products (6m_diff)			85%	86%	47%	3%	0.15	0.41
	MFG Stocks of Finished Products (12m_diff)			89%	86%	53%	5%	0.15	0.36
	Retail Sales (6m_ret)			90%	86%	51%	4%	0.15	0.38
	Retail Sales (12m_ret)			87%	82%	47%	8%	0.19	0.42
	New Passenger Cars (6m_ret)			75%	78%	12%	3%	0.24	0.67
New Passenger Cars (12m_ret)			80%	81%	33%	5%	0.21	0.52	
Inflation	HICP (6m_ret)			72%	79%	7%	0%	0.23	0.70
	HICP (12m_ret)			86%	86%	37%	0%	0.16	0.47
	HICP excl. Energy, Food, Alcohol & Tobacco (6m_ret)			69%	74%	0%	4%	0.28	0.76
	HICP excl. Energy, Food, Alcohol & Tobacco (12m_ret)			70%	72%	0%	6%	0.30	0.77
	Domestic PPI: Industry excluding Construction (6m_ret)			68%	77%	0%	0%	0.25	0.75
	Domestic PPI: Industry excluding Construction (12m_ret)			78%	81%	28%	3%	0.20	0.55
Commodities	Crude Oil			82%	80%	37%	8%	0.21	0.49
	Crude Oil (6m_diff)			53%	77%	0%	0%	0.25	0.75
	Crude Oil (12m_diff)			51%	77%	0%	0%	0.25	0.75
	Gold			76%	88%	51%	1%	0.13	0.37
	Gold (6m_diff)			56%	77%	0%	0%	0.25	0.75
	Gold (12m_diff)			60%	77%	0%	0%	0.25	0.75
Wealth	ESTOXX50 (6m_ret)			74%	79%	23%	5%	0.23	0.59
	ESTOXX50 (12m_ret)			77%	78%	21%	6%	0.24	0.61
	Residential Building Permits (6m_ret)			78%	84%	40%	3%	0.17	0.46
	Residential Building Permits (12m_ret)			81%	82%	40%	5%	0.19	0.47

Table A10: The Univariate Benchmark Model over the 18m Forecasting Horizon

18m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued No Signal Issued	A C	B D					L = 0.25	L = 0.75
Rates	3m EURIBOR	65%	69%	65%	69%	39%	13%	0.25	0.49
	3m EURIBOR (6m_diff)	38%	62%	38%	62%	0%	0%	0.25	0.75
	3m EURIBOR (12m_diff)	68%	68%	68%	68%	22%	4%	0.22	0.59
	10Yr German Government Bond	52%	62%	52%	62%	0%	0%	0.25	0.75
	10Yr German Government Bond (6m_diff)	54%	63%	54%	63%	3%	0%	0.24	0.73
	10Yr German Government Bond (12m_diff)	51%	62%	51%	62%	0%	0%	0.25	0.75
Term Spread	Term Spread: 10y-3m	70%	70%	70%	70%	46%	15%	0.25	0.44
	Term Spread: 10y-3m (6m_diff)	56%	62%	56%	62%	0%	0%	0.25	0.75
	Term Spread: 10y-3m (12m_diff)	71%	66%	71%	66%	25%	9%	0.26	0.58
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate]	84%	76%	84%	76%	61%	15%	0.21	0.33
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate] (6m_diff)	66%	69%	66%	69%	18%	0%	0.21	0.62
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate] (12m_diff)	79%	76%	79%	76%	67%	19%	0.22	0.29
Money Supply	M1 (6m_ret)	84%	79%	84%	79%	66%	13%	0.18	0.29
	M1 (12m_ret)	89%	79%	89%	79%	73%	17%	0.19	0.24
	Real M1 (6m_ret)	84%	78%	84%	78%	67%	15%	0.19	0.28
	Real M1 (12m_ret)	90%	81%	90%	81%	75%	15%	0.17	0.23
	M2 (6m_ret)	52%	62%	52%	62%	0%	0%	0.25	0.75
	M2 (12m_ret)	52%	62%	52%	62%	0%	0%	0.25	0.75
	Real M2 (6m_ret)	50%	62%	50%	62%	0%	0%	0.25	0.75
	Real M2 (12m_ret)	49%	62%	49%	62%	0%	0%	0.25	0.75
	M3 (6m_ret)	50%	62%	50%	62%	0%	0%	0.25	0.75
	M3 (12m_ret)	49%	62%	49%	62%	0%	0%	0.25	0.75
	Real M3 (6m_ret)	52%	62%	52%	62%	0%	0%	0.25	0.75
	Real M3 (12m_ret)	51%	62%	51%	62%	0%	0%	0.25	0.75
Competitiveness	FX EUR/USD	82%	70%	82%	70%	54%	20%	0.27	0.40
	FX EUR/USD (6m_ret)	54%	64%	54%	64%	6%	0%	0.24	0.71
	FX EUR/USD (12m_ret)	54%	62%	54%	62%	0%	0%	0.25	0.75
	JPM Nominal Broad Effective FX Rate	64%	63%	64%	63%	24%	12%	0.28	0.60
	JPM Nominal Broad Effective FX Rate (6m_ret)	61%	59%	61%	59%	10%	10%	0.30	0.70
	JPM Nominal Broad Effective FX Rate (12m_ret)	64%	63%	64%	63%	28%	16%	0.30	0.58
	Terms of Trade	82%	74%	82%	74%	66%	20%	0.24	0.31
	Terms of Trade (6m_ret)	64%	64%	64%	64%	12%	4%	0.25	0.67
	Terms of Trade (12m_ret)	72%	65%	72%	65%	49%	23%	0.31	0.44
	PMI	57%	71%	57%	71%	30%	4%	0.20	0.54
	PMI (6m_diff)	76%	73%	76%	73%	51%	14%	0.23	0.40
	PMI (12m_diff)	78%	74%	78%	74%	51%	12%	0.21	0.40
Sentiment	Economic Sentiment	48%	62%	48%	62%	0%	0%	0.25	0.75
	Economic Sentiment (6m_diff)	73%	75%	73%	75%	51%	9%	0.19	0.39
	Economic Sentiment (12m_diff)	64%	72%	64%	72%	36%	6%	0.20	0.50
	Industrial Confidence	60%	62%	60%	62%	0%	0%	0.25	0.75
	Industrial Confidence (6m_diff)	70%	74%	70%	74%	45%	7%	0.19	0.43
	Industrial Confidence (12m_diff)	61%	64%	61%	64%	12%	4%	0.25	0.67
	Consumer Confidence	62%	69%	62%	69%	28%	6%	0.23	0.55
	Consumer Confidence (6m_diff)	71%	71%	71%	71%	45%	12%	0.23	0.44
	Consumer Confidence (12m_diff)	62%	70%	62%	70%	42%	12%	0.24	0.47
	Consumer Economic Situation	67%	72%	67%	72%	49%	14%	0.23	0.42
	Consumer Economic Situation (6m_diff)	73%	70%	73%	70%	48%	17%	0.26	0.43
	Consumer Economic Situation (12m_diff)	69%	70%	69%	70%	45%	14%	0.24	0.45
	Business Climate	60%	62%	60%	62%	0%	0%	0.25	0.75
	Business Climate (6m_diff)	71%	78%	71%	78%	45%	8%	0.20	0.44
	Business Climate (12m_diff)	62%	64%	62%	64%	10%	3%	0.24	0.68
	Corporate Bonds: Investment Grade Spread	82%	83%	82%	83%	69%	8%	0.14	0.26
	Corporate Bonds: Investment Grade Spread (6m_diff)	64%	72%	64%	72%	30%	2%	0.19	0.53
	Corporate Bonds: Investment Grade Spread (12m_diff)	72%	77%	72%	77%	43%	3%	0.16	0.43
High Yield Spread	69%	66%	69%	66%	33%	13%	0.27	0.54	
High Yield Spread (6m_diff)	64%	71%	64%	71%	33%	5%	0.20	0.52	
High Yield Spread (12m_diff)	68%	76%	68%	76%	45%	5%	0.17	0.43	
EZ Peripheral Bond Spread	73%	73%	73%	73%	45%	10%	0.21	0.44	
EZ Peripheral Bond Spread (6m_diff)	80%	78%	80%	78%	45%	1%	0.15	0.42	
EZ Peripheral Bond Spread (12m_diff)	88%	81%	88%	81%	55%	3%	0.13	0.34	
MFI Loans to Private Sector (6m_ret)	54%	62%	54%	62%	0%	0%	0.25	0.75	
MFI Loans to Private Sector (12m_ret)	60%	68%	60%	68%	30%	8%	0.24	0.55	
Risk Aversion	Implied Rates Volatility	74%	74%	74%	74%	51%	11%	0.21	0.40
	Implied Rates Volatility (6m_diff)	63%	69%	63%	69%	33%	8%	0.23	0.52
	Implied Rates Volatility (12m_diff)	62%	66%	62%	66%	22%	6%	0.24	0.60
	VSTOXX	63%	62%	63%	62%	12%	7%	0.28	0.68
	VSTOXX (6m_ret)	57%	61%	57%	61%	7%	6%	0.27	0.71
	VSTOXX (12m_ret)	64%	61%	64%	61%	15%	10%	0.29	0.66
	VIX	69%	64%	69%	64%	28%	14%	0.28	0.57
	VIX (6m_ret)	59%	65%	59%	65%	24%	9%	0.26	0.59
	VIX (12m_ret)	68%	69%	68%	69%	37%	11%	0.24	0.50
	FX Basis EUR/USD	77%	71%	77%	71%	55%	19%	0.25	0.38
	FX Basis EUR/USD (6m_diff)	57%	65%	57%	65%	9%	0%	0.23	0.68
	FX Basis EUR/USD (12m_diff)	70%	74%	70%	74%	37%	4%	0.18	0.48
	Implied FX Vol	62%	70%	62%	70%	30%	5%	0.21	0.54
	Implied FX Vol (6m_ret)	56%	65%	56%	65%	15%	4%	0.24	0.65
	Implied FX Vol (12m_ret)	59%	65%	59%	65%	16%	6%	0.25	0.64
	LaborOIS	75%	79%	75%	79%	55%	6%	0.16	0.35
	Industrial Production: Industry excl. Constr. (6m_ret)	53%	65%	53%	65%	10%	2%	0.24	0.68
	Industrial Production: Industry excl. Constr. (12m_ret)	60%	62%	60%	62%	0%	0%	0.25	0.75
Unemployment Rate	61%	74%	61%	74%	31%	0%	0.17	0.51	
Unemployment Rate (6m_ret)	58%	64%	58%	64%	10%	3%	0.24	0.68	
Unemployment Rate (12m_ret)	51%	62%	51%	62%	0%	0%	0.25	0.75	
Manufact. New Orders (6m_ret)	53%	65%	53%	65%	10%	1%	0.23	0.67	
Manufact. New Orders (12m_ret)	57%	62%	57%	62%	0%	0%	0.25	0.75	
Industr. Turnover: Manufacturing (6m_ret)	43%	62%	43%	62%	0%	0%	0.25	0.75	
Industr. Turnover: Manufacturing (12m_ret)	70%	68%	70%	68%	19%	2%	0.22	0.61	
MFG Stocks of Finished Products	64%	66%	64%	66%	10%	0%	0.22	0.67	
MFG Stocks of Finished Products (6m_diff)	69%	71%	69%	71%	43%	11%	0.23	0.45	
MFG Stocks of Finished Products (12m_diff)	63%	69%	63%	69%	22%	3%	0.21	0.59	
Retail Sales (6m_ret)	75%	71%	75%	71%	48%	14%	0.23	0.43	
Retail Sales (12m_ret)	70%	71%	70%	71%	45%	13%	0.24	0.45	
New Passenger Cars (6m_ret)	73%	71%	73%	71%	42%	11%	0.23	0.46	
New Passenger Cars (12m_ret)	80%	75%	80%	75%	54%	12%	0.21	0.38	
Inflation	HICP (6m_ret)	70%	71%	70%	71%	37%	7%	0.21	0.49
	HICP (12m_ret)	75%	67%	75%	67%	52%	23%	0.29	0.42
	HICP excl. Energy, Food, Alcohol & Tobacco (6m_ret)	66%	59%	66%	59%	15%	14%	0.32	0.67
	HICP excl. Energy, Food, Alcohol & Tobacco (12m_ret)	63%	54%	63%	54%	0%	12%	0.34	0.78
	Domestic PPI: Industry excluding Construction (6m_ret)	74%	66%	74%	66%	31%	12%	0.26	0.55
	Domestic PPI: Industry excluding Construction (12m_ret)	81%	70%	81%	70%	57%	22%	0.27	0.38
Commodities	Crude Oil	79%	78%	79%	78%	61%	19%	0.24	0.34
	Crude Oil (6m_diff)	53%	62%	53%	62%	0%	0%	0.25	0.75
	Crude Oil (12m_diff)	50%	62%	50%	62%	0%	0%	0.25	0.75
	Gold	76%	65%	76%	65%	49%	25%	0.31	0.44
	Gold (6m_diff)	58%	62%	58%	62%	7%	4%	0.26	0.70
	Gold (12m_diff)	67%	65%	67%	65%	28%	12%	0.27	0.57
Wealth	ESTOXX50 (6m_ret)	64%	66%	64%	66%	27%	10%	0.26	0.57
	ESTOXX50 (12m_ret)	65%	60%	65%	60%	24%	18%	0.32	0.61
	Residential Building Permits (6m_ret)	69%	67%	69%	67%	40%	16%	0.27	0.49
	Residential Building Permits (12m_ret)	68%	65%	68%	65%	30%	13%	0.27	0.56

Table A11: The Univariate Benchmark Model over the 24m Forecasting Horizon

24m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B + D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued No Signal Issued	A C	B D					L = 0.25	L = 0.75
Rates	3m EURIBOR			63%	59%	42%	27%	0.35	0.50
	3m EURIBOR (6m_diff)			64%	53%	0%	0%	0.25	0.75
	3m EURIBOR (12m_diff)			68%	75%	59%	12%	0.19	0.33
	10yr German Government Bond			51%	48%	19%	27%	0.40	0.67
	10yr German Government Bond (6m_diff)			50%	56%	5%	0%	0.24	0.71
	10yr German Government Bond (12m_diff)			57%	56%	37%	28%	0.37	0.54
Term Spread	Term Spread: 10y-3m			67%	64%	53%	26%	0.31	0.42
	Term Spread: 10y-3m (6m_diff)			55%	60%	15%	0%	0.21	0.64
	Term Spread: 10y-3m (12m_diff)			64%	63%	56%	30%	0.34	0.41
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate]			80%	75%	70%	21%	0.23	0.28
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate] (6m_diff)			64%	62%	43%	22%	0.31	0.48
	Term Spread: 10y-Switch[3m Euribor/Shadow Rate] (12m_diff)			73%	71%	71%	29%	0.29	0.29
Money Supply	M1 (6m_ret)			79%	70%	67%	27%	0.28	0.31
	M1 (12m_ret)			80%	74%	77%	29%	0.27	0.24
	Real M1 (6m_ret)			79%	70%	67%	28%	0.29	0.32
	Real M1 (12m_ret)			81%	73%	77%	30%	0.28	0.25
	M2 (6m_ret)			50%	53%	0%	0%	0.25	0.75
	M2 (12m_ret)			50%	53%	0%	0%	0.25	0.75
	Real M2 (6m_ret)			53%	53%	0%	0%	0.25	0.75
	Real M2 (12m_ret)			48%	53%	0%	0%	0.25	0.75
	M3 (6m_ret)			52%	59%	16%	3%	0.23	0.63
	Real M3 (6m_ret)			51%	63%	25%	3%	0.21	0.57
Competitiveness	FX EUR/USD			84%	72%	70%	27%	0.28	0.29
	FX EUR/USD (6m_ret)			51%	54%	13%	10%	0.29	0.68
	FX EUR/USD (12m_ret)			51%	53%	0%	0%	0.25	0.75
	JPM Nominal Broad Effective FX Rate			69%	63%	57%	32%	0.35	0.40
	JPM Nominal Broad Effective FX Rate (6m_ret)			57%	53%	32%	29%	0.39	0.58
	JPM Nominal Broad Effective FX Rate (12m_ret)			62%	54%	41%	33%	0.40	0.53
	Terms of Trade			79%	70%	68%	28%	0.29	0.31
	Terms of Trade (6m_ret)			66%	61%	54%	33%	0.36	0.43
	Terms of Trade (12m_ret)			71%	68%	65%	29%	0.31	0.34
	PMI			48%	62%	30%	10%	0.25	0.55
Sentiment	PMI (6m_diff)			68%	64%	56%	28%	0.32	0.40
	PMI (12m_diff)			66%	66%	52%	22%	0.29	0.42
	Economic Sentiment			45%	53%	0%	0%	0.25	0.75
	Economic Sentiment (6m_diff)			62%	64%	49%	23%	0.30	0.44
	Economic Sentiment (12m_diff)			53%	65%	35%	9%	0.23	0.51
	Industrial Confidence			60%	73%	43%	1%	0.15	0.43
	Industrial Confidence (6m_diff)			59%	68%	46%	12%	0.23	0.44
	Industrial Confidence (12m_diff)			51%	56%	6%	0%	0.23	0.70
	Consumer Confidence			59%	63%	48%	23%	0.30	0.45
	Consumer Confidence (6m_diff)			63%	61%	41%	21%	0.31	0.50
	Consumer Confidence (12m_diff)			53%	62%	43%	22%	0.31	0.48
	Consumer Economic Situation			61%	64%	48%	22%	0.30	0.44
	Consumer Economic Situation (6m_diff)			66%	62%	47%	26%	0.32	0.46
	Consumer Economic Situation (12m_diff)			60%	61%	43%	23%	0.32	0.49
	Business Climate			61%	72%	41%	1%	0.16	0.45
	Business Climate (6m_diff)			59%	67%	46%	14%	0.24	0.44
Business Climate (12m_diff)			53%	57%	8%	0%	0.23	0.69	
Refinancing	Corporate Bonds: Investment Grade Spread			79%	82%	73%	10%	0.14	0.22
	Corporate Bonds: Investment Grade Spread (6m_diff)			60%	65%	41%	13%	0.25	0.48
	Corporate Bonds: Investment Grade Spread (12m_diff)			66%	68%	42%	9%	0.21	0.46
	High Yield Spread			65%	63%	46%	21%	0.29	0.46
	High Yield Spread (6m_diff)			59%	59%	34%	19%	0.31	0.54
	High Yield Spread (12m_diff)			61%	69%	42%	7%	0.20	0.45
	EZ Peripheral Bond Spread			70%	60%	43%	24%	0.33	0.49
	EZ Peripheral Bond Spread (6m_diff)			81%	78%	57%	3%	0.13	0.33
	EZ Peripheral Bond Spread (12m_diff)			83%	79%	59%	4%	0.13	0.31
	MFI Loans to Private Sector (6m_ret)			56%	59%	39%	23%	0.33	0.51
MFI Loans to Private Sector (12m_ret)			61%	57%	43%	30%	0.37	0.50	
Risk Aversion	Implied Rates Volatility			71%	68%	52%	18%	0.25	0.41
	Implied Rates Volatility (6m_diff)			57%	59%	37%	22%	0.32	0.53
	Implied Rates Volatility (12m_diff)			55%	53%	29%	26%	0.37	0.60
	VSTOXX			62%	56%	28%	19%	0.32	0.59
	VSTOXX (6m_ret)			57%	57%	27%	16%	0.30	0.59
	VSTOXX (12m_ret)			60%	59%	38%	22%	0.32	0.52
	VIX			67%	63%	46%	21%	0.29	0.46
	VIX (6m_ret)			57%	63%	35%	13%	0.26	0.52
	VIX (12m_ret)			62%	63%	43%	20%	0.29	0.48
	FX Basis EUR/USD			77%	72%	66%	22%	0.25	0.31
Industrial Data	FX Basis EUR/USD (6m_diff)			56%	63%	22%	1%	0.20	0.59
	FX Basis EUR/USD (12m_diff)			66%	63%	37%	13%	0.26	0.51
	Implied FX Vol			60%	63%	44%	20%	0.29	0.47
	Implied FX Vol (6m_ret)			53%	57%	20%	11%	0.28	0.63
	Implied FX Vol (12m_ret)			50%	56%	16%	9%	0.28	0.65
	LiborOIS			65%	73%	49%	6%	0.17	0.39
	Industrial Production: Industry excl. Constr. (6m_ret)			43%	57%	10%	2%	0.24	0.68
	Industrial Production: Industry excl. Constr. (12m_ret)			62%	62%	19%	0%	0.20	0.61
	Unemployment Rate			62%	44%	46%	58%	0.57	0.55
	Unemployment Rate (6m_ret)			55%	67%	38%	8%	0.21	0.48
Unemployment Rate (12m_ret)			51%	57%	13%	4%	0.25	0.67	
Manufact. New Orders (6m_ret)			45%	61%	18%	1%	0.21	0.62	
Manufact. New Orders (12m_ret)			61%	70%	42%	4%	0.18	0.45	
Industr. Turnover: Manufacturing (6m_ret)			65%	54%	3%	0%	0.24	0.73	
Industr. Turnover: Manufacturing (12m_ret)			70%	70%	59%	20%	0.25	0.35	
MFG Stocks of Finished Products			69%	62%	51%	29%	0.34	0.44	
MFG Stocks of Finished Products (6m_diff)			58%	62%	38%	18%	0.29	0.51	
MFG Stocks of Finished Products (12m_diff)			49%	54%	3%	0%	0.24	0.73	
Retail Sales (6m_ret)			71%	69%	58%	22%	0.27	0.37	
Retail Sales (12m_ret)			69%	66%	54%	23%	0.29	0.40	
New Passenger Cars (6m_ret)			73%	69%	59%	22%	0.27	0.36	
New Passenger Cars (12m_ret)			72%	69%	63%	27%	0.29	0.34	
Inflation	HICP (6m_ret)			68%	62%	61%	38%	0.38	0.39
	HICP (12m_ret)			71%	56%	58%	46%	0.45	0.43
	HICP excl. Energy, Food, Alcohol & Tobacco (6m_ret)			59%	50%	28%	30%	0.41	0.62
	HICP excl. Energy, Food, Alcohol & Tobacco (12m_ret)			55%	46%	0%	14%	0.36	0.79
	Domestic PPI: Industry excluding Construction (6m_ret)			75%	69%	66%	29%	0.30	0.33
Domestic PPI: Industry excluding Construction (12m_ret)			79%	73%	73%	27%	0.27	0.27	
Commodities	Crude Oil			79%	75%	71%	22%	0.24	0.27
	Crude Oil (6m_diff)			50%	54%	3%	0%	0.24	0.73
	Crude Oil (12m_diff)			55%	52%	30%	29%	0.39	0.59
	Gold			75%	57%	52%	39%	0.41	0.46
	Gold (6m_diff)			68%	64%	54%	28%	0.32	0.41
Wealth	Gold (12m_diff)			77%	72%	67%	24%	0.27	0.31
	ESTOXS50 (6m_ret)			62%	58%	37%	23%	0.33	0.53
	ESTOXS50 (12m_ret)			58%	57%	34%	23%	0.34	0.55
	Residential Building Permits (6m_ret)			67%	62%	48%	27%	0.33	0.46
	Residential Building Permits (12m_ret)			66%	63%	46%	22%	0.30	0.46

Table A12: Submodel 1 - Monetary Transmission Channels over Various Time Horizons

6 months

6m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued No Signal Issued	A C	B D					L=0.25	L=0.75
Channel: Money Supply				95%	92%	72%	2%	0.09	0.21
Real M1 (12m_ret)				94%	91%	70%	2%	0.09	0.23
Channel: Competitiveness				92%	86%	65%	8%	0.15	0.28
FX EUR/USD				81%	81%	40%	6%	0.20	0.47
Terms of Trade				88%	83%	63%	10%	0.17	0.31
Channel: Sentiment				93%	90%	70%	4%	0.11	0.24
PMI (12m_diff)				95%	90%	74%	5%	0.10	0.20
Economic Sentiment (6m_diff)				94%	90%	70%	3%	0.10	0.24
Industrial Confidence (6m_diff)				92%	89%	65%	4%	0.12	0.27
Business Climate (6m_diff)				93%	89%	65%	4%	0.12	0.27
Consumer Economic Situation (12m_diff)				89%	87%	65%	6%	0.13	0.28
Consumer Confidence (6m_diff)				89%	88%	63%	5%	0.13	0.29
Channel: Refinancing				89%	88%	56%	3%	0.13	0.34
Corporate Bonds: Investment Grade Spread				91%	85%	51%	5%	0.16	0.38
EZ Peripheral Bond Spread (12m_diff)				83%	82%	30%	3%	0.20	0.53
High Yield Spread (12m_diff)				80%	80%	1%	1%	0.11	0.32
Channel: Preference for Risk				93%	88%	60%	4%	0.13	0.31
LiborOIS				90%	87%	51%	2%	0.14	0.37
Implied Rates Volatility				83%	81%	35%	6%	0.20	0.50
FX Basis EUR/USD				80%	82%	40%	6%	0.19	0.47
Channel: Industrial Data				95%	90%	72%	4%	0.10	0.22
Retail Sales (6m_ret)				90%	86%	51%	4%	0.15	0.38
MFG Stocks of Finished Products (6m_diff)				85%	86%	47%	3%	0.15	0.41
New Passenger Cars (12m_ret)				80%	81%	33%	5%	0.21	0.52
Channel: Inflation				86%	87%	49%	2%	0.14	0.39
HICP (12m_ret)				86%	86%	37%	0%	0.16	0.47
Domestic PPI: Industry excluding Construction (12m_ret)				78%	81%	28%	3%	0.20	0.55
Channel: Commodities				83%	85%	42%	2%	0.16	0.44
Crude Oil				82%	80%	37%	8%	0.21	0.49
Gold				76%	88%	51%	1%	0.13	0.37

18 months

18m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued No Signal Issued	A C	B D					L=0.25	L=0.75
Channel: Money Supply				90%	81%	75%	15%	0.17	0.23
Real M1 (12m_ret)				90%	81%	75%	15%	0.17	0.23
Channel: Competitiveness				85%	74%	66%	20%	0.24	0.31
FX EUR/USD				82%	70%	54%	20%	0.27	0.40
Terms of Trade				82%	74%	66%	20%	0.24	0.31
Channel: Sentiment				69%	76%	48%	6%	0.18	0.41
PMI (12m_diff)				78%	74%	51%	12%	0.21	0.40
Economic Sentiment (6m_diff)				73%	75%	51%	9%	0.19	0.39
Industrial Confidence (6m_diff)				70%	74%	45%	7%	0.19	0.43
Business Climate (6m_diff)				71%	74%	45%	8%	0.20	0.44
Consumer Economic Situation (12m_diff)				69%	70%	45%	14%	0.24	0.45
Consumer Confidence (6m_diff)				71%	71%	45%	12%	0.23	0.44
Channel: Refinancing				83%	83%	66%	6%	0.13	0.27
Corporate Bonds: Investment Grade Spread				82%	83%	69%	8%	0.14	0.26
EZ Peripheral Bond Spread (12m_diff)				88%	81%	55%	3%	0.13	0.34
High Yield Spread (12m_diff)				68%	76%	45%	5%	0.17	0.43
Channel: Preference for Risk				79%	81%	61%	6%	0.15	0.31
LiborOIS				75%	79%	55%	6%	0.16	0.35
Implied Rates Volatility				74%	74%	51%	11%	0.21	0.40
FX Basis EUR/USD				77%	71%	55%	19%	0.25	0.38
Channel: Industrial Data				82%	79%	60%	9%	0.17	0.33
Retail Sales (6m_ret)				75%	71%	48%	14%	0.23	0.43
MFG Stocks of Finished Products (6m_diff)				69%	71%	43%	11%	0.23	0.45
New Passenger Cars (12m_ret)				80%	75%	54%	12%	0.21	0.38
Channel: Inflation				81%	71%	58%	21%	0.26	0.37
HICP (12m_ret)				75%	67%	52%	23%	0.29	0.42
Domestic PPI: Industry excluding Construction (12m_ret)				81%	70%	57%	22%	0.27	0.38
Channel: Commodities				83%	74%	70%	23%	0.25	0.28
Crude Oil				79%	74%	61%	19%	0.24	0.34
Gold				76%	65%	49%	25%	0.31	0.44

24 months

24m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued No Signal Issued	A C	B D					L=0.25	L=0.75
Channel: Money Supply				79%	72%	76%	31%	0.29	0.26
Real M1 (12m_ret)				81%	73%	77%	30%	0.28	0.25
Channel: Competitiveness				84%	73%	73%	28%	0.27	0.27
FX EUR/USD				84%	72%	70%	27%	0.28	0.29
Terms of Trade				79%	70%	68%	28%	0.29	0.31
Channel: Sentiment				58%	64%	47%	2%	0.28	0.45
PMI (12m_diff)				66%	66%	52%	22%	0.29	0.42
Economic Sentiment (6m_diff)				62%	64%	49%	23%	0.30	0.44
Industrial Confidence (6m_diff)				59%	68%	46%	12%	0.23	0.44
Business Climate (6m_diff)				59%	67%	46%	14%	0.24	0.44
Consumer Economic Situation (12m_diff)				60%	61%	43%	23%	0.32	0.49
Consumer Confidence (6m_diff)				63%	61%	41%	21%	0.31	0.50
Channel: Refinancing				76%	76%	59%	10%	0.18	0.33
Corporate Bonds: Investment Grade Spread				79%	82%	73%	10%	0.14	0.22
EZ Peripheral Bond Spread (12m_diff)				83%	79%	59%	4%	0.13	0.31
High Yield Spread (12m_diff)				61%	69%	42%	7%	0.20	0.45
Channel: Preference for Risk				75%	77%	65%	12%	0.18	0.30
LiborOIS				65%	73%	49%	6%	0.17	0.39
Implied Rates Volatility				71%	68%	52%	18%	0.25	0.41
FX Basis EUR/USD				77%	72%	66%	22%	0.25	0.31
Channel: Industrial Data				69%	72%	58%	17%	0.23	0.35
Retail Sales (6m_ret)				71%	69%	58%	22%	0.27	0.37
MFG Stocks of Finished Products (6m_diff)				58%	62%	38%	18%	0.29	0.51
New Passenger Cars (12m_ret)				72%	69%	63%	27%	0.29	0.34
Channel: Inflation				78%	73%	73%	28%	0.27	0.27
HICP (12m_ret)				71%	56%	58%	46%	0.45	0.43
Domestic PPI: Industry excluding Construction (12m_ret)				79%	73%	73%	27%	0.27	0.27
Channel: Commodities				83%	79%	82%	23%	0.22	0.19
Crude Oil				79%	75%	71%	22%	0.24	0.27
Gold				75%	57%	52%	39%	0.41	0.46

Table A13: Submodel 2 - Bivariate Specification over Various Time Horizons

6 months

6m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued	A	B					L= 0.25	L= 0.75
	No Signal Issued	C	D						
Single Indicators	Real M1 (12m_ret) & PMI (12m_diff)	99%	95%	99%	95%	84%	2%	0.06	0.13
	Real M1 (12m_ret) & Investment Grade Spreads	98%	94%	98%	94%	84%	3%	0.07	0.13
	Real M1 (12m_ret) & Terms of Trade	95%	91%	95%	91%	72%	3%	0.09	0.22
	Real M1 (12m_ret) & Retail Sales (6m_ret)	99%	94%	99%	94%	81%	3%	0.07	0.15
	Real M1 (12m_ret) & Crude Oil	94%	91%	94%	91%	70%	3%	0.10	0.23
	PMI (12m_diff) & Investment Grade Spreads	98%	93%	98%	93%	77%	2%	0.07	0.18
	PMI (12m_diff) & Terms of Trade	100%	98%	100%	98%	93%	1%	0.02	0.05
	PMI (12m_diff) & Retail Sales (6m_ret)	97%	91%	97%	91%	81%	6%	0.09	0.15
	PMI (12m_diff) & Crude Oil	100%	97%	100%	97%	93%	1%	0.03	0.06
	Corporate Investment Grade Spreads & Terms of Trade	95%	91%	95%	91%	79%	5%	0.09	0.17
	Corporate Investment Grade Spreads & Retail Sales (6m_ret)	95%	88%	95%	88%	63%	4%	0.12	0.29
	Corporate Investment Grade Spreads & Crude Oil	96%	91%	96%	91%	79%	5%	0.09	0.17
	Terms of Trade & Retail Sales (6m_ret)	96%	90%	96%	90%	74%	5%	0.10	0.20
	Terms of Trade & Crude Oil	88%	83%	88%	83%	65%	12%	0.18	0.29
	Retail Sales (6m_ret) & Crude Oil	94%	89%	94%	89%	70%	6%	0.12	0.24
	Channels: Money Supply & Industrial	99%	97%	99%	97%	93%	2%	0.03	0.06
	Channels: Money Supply & Refinancing	98%	93%	98%	93%	79%	3%	0.07	0.16
	Channels: Money Supply & Competitiveness	96%	92%	96%	92%	72%	2%	0.09	0.21
	Channels: Money Supply & Sentiment	100%	96%	100%	96%	88%	1%	0.04	0.09
	Channels: Money Supply & Commodities	95%	92%	95%	92%	72%	2%	0.09	0.21
Channels: Industrial & Refinancing	97%	91%	97%	91%	77%	4%	0.09	0.18	
Channels: Industrial & Competitiveness	99%	94%	99%	94%	88%	4%	0.06	0.10	
Channels: Industrial & Sentiment	96%	93%	96%	93%	84%	4%	0.07	0.13	
Channels: Industrial & Commodities	98%	93%	98%	93%	86%	5%	0.07	0.12	
Channels: Refinancing & Competitiveness	98%	92%	98%	92%	79%	4%	0.08	0.17	
Channels: Refinancing & Sentiment	95%	91%	95%	91%	74%	3%	0.09	0.20	
Channels: Refinancing & Commodities	97%	91%	97%	91%	79%	5%	0.09	0.17	
Channels: Competitiveness & Sentiment	100%	98%	100%	98%	95%	1%	0.02	0.04	
Channels: Competitiveness & Commodities	94%	87%	94%	87%	70%	8%	0.14	0.25	
Channels: Sentiment & Commodities	100%	100%	100%	100%	100%	0%	0.00	0.00	

18 months

18m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued	A	B					L= 0.25	L= 0.75
	No Signal Issued	C	D						
Single Indicators	Real M1 (12m_ret) & PMI (12m_diff)	92%	87%	92%	87%	78%	7%	0.11	0.19
	Real M1 (12m_ret) & Investment Grade Spreads	93%	83%	93%	83%	73%	10%	0.14	0.23
	Real M1 (12m_ret) & Terms of Trade	92%	79%	92%	79%	73%	18%	0.20	0.25
	Real M1 (12m_ret) & Retail Sales (6m_ret)	91%	82%	91%	82%	73%	12%	0.16	0.23
	Real M1 (12m_ret) & Crude Oil	90%	81%	90%	81%	75%	16%	0.18	0.23
	PMI (12m_diff) & Investment Grade Spreads	85%	85%	85%	85%	69%	6%	0.12	0.25
	PMI (12m_diff) & Terms of Trade	89%	79%	89%	79%	66%	13%	0.18	0.29
	PMI (12m_diff) & Retail Sales (6m_ret)	79%	79%	79%	79%	63%	10%	0.17	0.31
	PMI (12m_diff) & Crude Oil	89%	81%	89%	81%	75%	16%	0.18	0.23
	Corporate Investment Grade Spreads & Terms of Trade	88%	82%	88%	82%	75%	14%	0.17	0.23
	Corporate Investment Grade Spreads & Retail Sales (6m_ret)	82%	85%	82%	85%	75%	8%	0.13	0.21
	Corporate Investment Grade Spreads & Crude Oil	89%	77%	89%	77%	79%	24%	0.23	0.22
	Terms of Trade & Retail Sales (6m_ret)	86%	78%	86%	78%	70%	18%	0.21	0.27
	Terms of Trade & Crude Oil	83%	75%	83%	75%	64%	19%	0.23	0.31
	Retail Sales (6m_ret) & Crude Oil	84%	74%	84%	74%	67%	21%	0.24	0.30
	Channels: Money Supply & Industrial	91%	84%	91%	84%	75%	10%	0.14	0.22
	Channels: Money Supply & Refinancing	93%	85%	93%	85%	70%	6%	0.12	0.24
	Channels: Money Supply & Competitiveness	92%	81%	92%	81%	78%	17%	0.18	0.21
	Channels: Money Supply & Sentiment	90%	87%	90%	87%	76%	6%	0.11	0.20
	Channels: Money Supply & Commodities	92%	79%	92%	79%	76%	19%	0.20	0.23
Channels: Industrial & Refinancing	87%	86%	87%	86%	70%	5%	0.11	0.24	
Channels: Industrial & Competitiveness	92%	81%	92%	81%	75%	16%	0.18	0.23	
Channels: Industrial & Sentiment	82%	80%	82%	80%	63%	9%	0.16	0.30	
Channels: Industrial & Commodities	93%	85%	93%	85%	78%	10%	0.13	0.19	
Channels: Refinancing & Competitiveness	93%	86%	93%	86%	76%	7%	0.12	0.20	
Channels: Refinancing & Sentiment	83%	83%	83%	83%	66%	6%	0.13	0.27	
Channels: Refinancing & Commodities	94%	88%	94%	88%	81%	7%	0.10	0.17	
Channels: Competitiveness & Sentiment	91%	79%	91%	79%	70%	15%	0.19	0.26	
Channels: Competitiveness & Commodities	85%	75%	85%	75%	67%	20%	0.23	0.30	
Channels: Sentiment & Commodities	92%	82%	92%	82%	75%	13%	0.16	0.22	

24 months

24m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) *	
	Signal Issued	A	B					L= 0.25	L= 0.75
	No Signal Issued	C	D						
Single Indicators	Real M1 (12m_ret) & PMI (12m_diff)	80%	72%	80%	72%	76%	32%	0.30	0.26
	Real M1 (12m_ret) & Investment Grade Spreads	85%	74%	85%	74%	67%	20%	0.23	0.30
	Real M1 (12m_ret) & Terms of Trade	86%	77%	86%	77%	77%	23%	0.23	0.23
	Real M1 (12m_ret) & Retail Sales (6m_ret)	82%	73%	82%	73%	71%	24%	0.26	0.28
	Real M1 (12m_ret) & Crude Oil	85%	73%	85%	73%	67%	22%	0.25	0.30
	PMI (12m_diff) & Investment Grade Spreads	79%	83%	79%	83%	73%	9%	0.13	0.22
	PMI (12m_diff) & Terms of Trade	81%	66%	81%	66%	59%	28%	0.31	0.37
	PMI (12m_diff) & Retail Sales (6m_ret)	70%	69%	70%	69%	57%	21%	0.27	0.38
	PMI (12m_diff) & Crude Oil	82%	69%	82%	69%	62%	24%	0.28	0.35
	Corporate Investment Grade Spreads & Terms of Trade	85%	74%	85%	74%	71%	23%	0.25	0.28
	Corporate Investment Grade Spreads & Retail Sales (6m_ret)	79%	82%	79%	82%	73%	10%	0.14	0.22
	Corporate Investment Grade Spreads & Crude Oil	88%	76%	88%	76%	77%	26%	0.25	0.23
	Terms of Trade & Retail Sales (6m_ret)	83%	69%	83%	69%	62%	26%	0.29	0.35
	Terms of Trade & Crude Oil	82%	72%	82%	72%	68%	24%	0.26	0.30
	Retail Sales (6m_ret) & Crude Oil	82%	72%	82%	72%	70%	27%	0.28	0.29
	Channels: Money Supply & Industrial	80%	71%	80%	71%	73%	31%	0.30	0.28
	Channels: Money Supply & Refinancing	82%	79%	82%	79%	62%	7%	0.14	0.30
	Channels: Money Supply & Competitiveness	86%	75%	86%	75%	75%	26%	0.25	0.25
	Channels: Money Supply & Sentiment	79%	72%	79%	72%	75%	31%	0.30	0.27
	Channels: Money Supply & Commodities	87%	76%	87%	76%	75%	23%	0.24	0.25
Channels: Industrial & Refinancing	86%	77%	86%	77%	59%	8%	0.16	0.32	
Channels: Industrial & Competitiveness	86%	72%	86%	72%	68%	26%	0.27	0.30	
Channels: Industrial & Sentiment	70%	70%	70%	70%	62%	22%	0.26	0.34	
Channels: Industrial & Commodities	87%	75%	87%	75%	73%	23%	0.24	0.26	
Channels: Refinancing & Competitiveness	89%	74%	89%	74%	70%	22%	0.24	0.28	
Channels: Refinancing & Sentiment	83%	76%	83%	76%	58%	9%	0.17	0.34	
Channels: Refinancing & Commodities	91%	76%	91%	76%	75%	22%	0.23	0.25	
Channels: Competitiveness & Sentiment	86%	71%	86%	71%	68%	27%	0.28	0.30	
Channels: Competitiveness & Commodities	84%	75%	84%	75%	76%	27%	0.26	0.25	
Channels: Sentiment & Commodities	87%	74%	87%	74%	73%	26%	0.26	0.26	

Table A14: Submodel 3 - Unstable Surges over Various Time Horizons

6 months

6m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive rate vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued	A	B					L= 0.25	L= 0.75
	No Signal Issued	C	D						
Money Supply	Real M1 & HP Diff Lag (t0)	97%	93%	84%	5%	0.08	0.13		
	Real M1 & HP Diff Lag (t-1yr)	100%	96%	93%	3%	0.04	0.06		
	Real M1 & HP Diff Lag (t-2yr)	94%	91%	70%	3%	0.10	0.23		
	Single Indicator: Real M1 (12m ret)	94%	91%	70%	2%	0.09	0.23		
Equity Markets	ESTOXX50 (12m_ret) & HP Diff Lag (t0)	76%	80%	26%	4%	0.22	0.57		
	ESTOXX50 (12m_ret) & HP Diff Lag (t-1yr)	77%	78%	21%	6%	0.24	0.61		
	ESTOXX50 (12m_ret) & HP Diff Lag (t-2yr)	78%	80%	33%	6%	0.22	0.52		
	Single Indicator: Real M1 (12m_ret)	77%	78%	21%	6%	0.24	0.61		
Building Permits	Residential Building Permits (6m_ret) & HP Diff Lag (t0)	86%	82%	47%	8%	0.19	0.42		
	Residential Building Permits (6m_ret) & HP Diff Lag (t-1yr)	82%	84%	42%	3%	0.17	0.44		
	Residential Building Permits (6m_ret) & HP Diff Lag (t-2yr)	81%	84%	44%	4%	0.17	0.43		
	Single Indicator: Residential Building Permits (6m_ret)	78%	84%	40%	3%	0.17	0.46		
Sentiment	PMI (12m_diff) & HP Diff Lag (t0)	97%	91%	81%	6%	0.09	0.15		
	PMI (12m_diff) & HP Diff Lag (t-1yr)	95%	90%	74%	5%	0.10	0.20		
	PMI (12m_diff) & HP Diff Lag (t-2yr)	94%	92%	74%	3%	0.08	0.20		
	Single Indicator: PMI (12m_diff)	95%	90%	74%	5%	0.10	0.20		
Inflation	HICP (12m_ret) & HP Diff Lag (t0)	86%	86%	37%	0%	0.16	0.47		
	HICP (12m_ret) & HP Diff Lag (t-1yr)	95%	91%	77%	4%	0.09	0.18		
	HICP (12m_ret) & HP Diff Lag (t-2yr)	86%	86%	47%	2%	0.15	0.41		
	Single Indicator: HICP (12m_ret)	86%	86%	37%	0%	0.16	0.47		
Retail	Retail Sales (6m_ret) & HP Diff Lag (t0)	94%	86%	74%	8%	0.13	0.21		
	Retail Sales (6m_ret) & HP Diff Lag (t-1yr)	91%	87%	53%	3%	0.14	0.36		
	Retail Sales (6m_ret) & HP Diff Lag (t-2yr)	91%	86%	49%	3%	0.15	0.39		
	Single Indicator: Retail Sales (6m_ret)	90%	86%	51%	4%	0.15	0.38		
Credit Dynamics	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t0)	82%	84%	42%	3%	0.17	0.44		
	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t-1yr)	77%	77%	23%	7%	0.24	0.59		
	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t-2yr)	61%	79%	9%	0%	0.23	0.68		
	Single Indicator: MFI Loans to Private Sector (12m_ret)	54%	67%	0%	0%	0.25%	0.75%		
Oil	Crude Oil & HP Diff Lag (t0)	89%	81%	53%	10%	0.37	0.57		
	Crude Oil & HP Diff Lag (t-1yr)	84%	76%	37%	12%	0.25	0.50		
	Crude Oil & HP Diff Lag (t-2yr)	85%	81%	42%	8%	0.20	0.46		
	Single Indicator: Crude Oil	82%	80%	37%	8%	0.21	0.49		
Central Bank Policy	3m EURIBOR (12m_diff) & HP Diff Lag (t0)	58%	77%	0%	0%	0.25	0.75		
	3m EURIBOR (12m_diff) & HP Diff Lag (t-1yr)	95%	89%	72%	6%	0.12	0.22		
	3m EURIBOR (12m_diff) & HP Diff Lag (t-2yr)	54%	77%	0%	0%	0.25	0.75		
	Single Indicator: 3m EURIBOR	62%	77%	0%	0%	0.25	0.75		

18 months

18m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive rate vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued	A	B					L= 0.25	L= 0.75
	No Signal Issued	C	D						
Money Supply	Real M1 & HP Diff Lag (t0)	94%	83%	79%	15%	0.16	0.19		
	Real M1 & HP Diff Lag (t-1yr)	90%	85%	82%	14%	0.15	0.26		
	Real M1 & HP Diff Lag (t-2yr)	90%	77%	72%	20%	0.22	0.26		
	Single Indicator: Real M1 (12m_ret)	90%	81%	75%	13%	0.17	0.23		
Equity Markets	ESTOXX50 (12m_ret) & HP Diff Lag (t0)	64%	62%	25%	16%	0.30	0.60		
	ESTOXX50 (12m_ret) & HP Diff Lag (t-1yr)	66%	65%	36%	17%	0.29	0.52		
	ESTOXX50 (12m_ret) & HP Diff Lag (t-2yr)	65%	61%	21%	14%	0.30	0.63		
	Single Indicator: Real M1 (12m_ret)	65%	60%	24%	18%	0.32	0.61		
Building Permits	Residential Building Permits (6m_ret) & HP Diff Lag (t0)	91%	79%	61%	9%	0.17	0.31		
	Residential Building Permits (6m_ret) & HP Diff Lag (t-1yr)	74%	71%	51%	17%	0.25	0.41		
	Residential Building Permits (6m_ret) & HP Diff Lag (t-2yr)	70%	69%	39%	13%	0.25	0.49		
	Single Indicator: Residential Building Permits (6m_ret)	69%	67%	40%	16%	0.27	0.49		
Sentiment	PMI (12m_diff) & HP Diff Lag (t0)	89%	84%	76%	11%	0.14	0.21		
	PMI (12m_diff) & HP Diff Lag (t-1yr)	81%	76%	63%	10%	0.21	0.32		
	PMI (12m_diff) & HP Diff Lag (t-2yr)	81%	75%	57%	13%	0.21	0.36		
	Single Indicator: PMI (12m_diff)	78%	74%	51%	12%	0.21	0.40		
Inflation	HICP (12m_ret) & HP Diff Lag (t0)	75%	66%	52%	25%	0.31	0.42		
	HICP (12m_ret) & HP Diff Lag (t-1yr)	75%	68%	52%	22%	0.29	0.41		
	HICP (12m_ret) & HP Diff Lag (t-2yr)	75%	70%	52%	19%	0.27	0.41		
	Single Indicator: HICP (12m_ret)	75%	67%	52%	23%	0.29	0.42		
Retail	Retail Sales (6m_ret) & HP Diff Lag (t0)	86%	83%	79%	14%	0.16	0.19		
	Retail Sales (6m_ret) & HP Diff Lag (t-1yr)	76%	73%	49%	12%	0.22	0.41		
	Retail Sales (6m_ret) & HP Diff Lag (t-2yr)	75%	72%	46%	12%	0.22	0.43		
	Single Indicator: Retail Sales (6m_ret)	75%	71%	48%	14%	0.23	0.43		
Credit Dynamics	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t0)	74%	70%	45%	14%	0.24	0.45		
	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t-1yr)	62%	75%	42%	4%	0.17	0.45		
	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t-2yr)	63%	59%	13%	12%	0.31	0.68		
	Single Indicator: MFI Loans to Private Sector (12m_ret)	60%	68%	30%	8%	0.24	0.55%		
Oil	Crude Oil & HP Diff Lag (t0)	88%	73%	64%	22%	0.26	0.32		
	Crude Oil & HP Diff Lag (t-1yr)	80%	71%	58%	20%	0.26	0.36		
	Crude Oil & HP Diff Lag (t-2yr)	80%	74%	61%	19%	0.24	0.34		
	Single Indicator: Crude Oil	79%	74%	61%	19%	0.24	0.34		
Central Bank Policy	3m EURIBOR (12m_diff) & HP Diff Lag (t0)	72%	77%	46%	4%	0.16	0.41		
	3m EURIBOR (12m_diff) & HP Diff Lag (t-1yr)	72%	81%	55%	4%	0.14	0.35		
	3m EURIBOR (12m_diff) & HP Diff Lag (t-2yr)	66%	74%	36%	2%	0.17	0.49		
	Single Indicator: 3m EURIBOR	65%	69%	39%	13%	0.25	0.49		

24 months

24m Forecasting Horizon				AUROC	Correct Signal	Crisis Detected	False Alarm	Risk-Affine	Risk-Averse
Transmission Channel	Classification	Recession	No Recession	True positive rate vs. False Positive Rate	(A+D)/(A+B+C+D)	A / (A + C)	A / (B+D)	L = f * (Type2Error) + (1 - f) * (Type1Error)	
	Signal Issued	A	B					L= 0.25	L= 0.75
	No Signal Issued	C	D						
Money Supply	Real M1 & HP Diff Lag (t0)	88%	79%	82%	24%	0.23	0.19		
	Real M1 & HP Diff Lag (t-1yr)	82%	73%	77%	31%	0.29	0.25		
	Real M1 & HP Diff Lag (t-2yr)	81%	73%	77%	31%	0.29	0.25		
	Single Indicator: Real M1 (12m_ret)	81%	73%	77%	30%	0.28	0.25		
Equity Markets	ESTOXX50 (12m_ret) & HP Diff Lag (t0)	61%	56%	33%	24%	0.35	0.56		
	ESTOXX50 (12m_ret) & HP Diff Lag (t-1yr)	57%	59%	38%	23%	0.33	0.52		
	ESTOXX50 (12m_ret) & HP Diff Lag (t-2yr)	58%	57%	35%	24%	0.34	0.55		
	Single Indicator: Real M1 (12m_ret)	58%	57%	34%	23%	0.34	0.55%		
Building Permits	Residential Building Permits (6m_ret) & HP Diff Lag (t0)	92%	88%	77%	7%	0.11	0.19		
	Residential Building Permits (6m_ret) & HP Diff Lag (t-1yr)	69%	64%	53%	27%	0.32	0.42		
	Residential Building Permits (6m_ret) & HP Diff Lag (t-2yr)	68%	62%	52%	29%	0.34	0.43		
	Single Indicator: Residential Building Permits (6m_ret)	67%	62%	48%	27%	0.33	0.46		
Sentiment	PMI (12m_diff) & HP Diff Lag (t0)	89%	77%	78%	24%	0.24	0.22		
	PMI (12m_diff) & HP Diff Lag (t-1yr)	64%	66%	53%	23%	0.29	0.41		
	PMI (12m_diff) & HP Diff Lag (t-2yr)	63%	64%	48%	21%	0.29	0.44		
	Single Indicator: PMI (12m_diff)	66%	66%	52%	22%	0.29	0.42		
Inflation	HICP (12m_ret) & HP Diff Lag (t0)	71%	57%	72%	57%	0.43	0.35		
	HICP (12m_ret) & HP Diff Lag (t-1yr)	71%	57%	62%	48%	0.45	0.40		
	HICP (12m_ret) & HP Diff Lag (t-2yr)	71%	56%	59%	47%	0.45	0.42		
	Single Indicator: HICP (12m_ret)	71%	56%	58%	46%	0.45	0.43		
Retail	Retail Sales (6m_ret) & HP Diff Lag (t0)	88%	83%	80%	14%	0.16	0.19		
	Retail Sales (6m_ret) & HP Diff Lag (t-1yr)	71%	69%	59%	22%	0.27	0.36		
	Retail Sales (6m_ret) & HP Diff Lag (t-2yr)	71%	68%	58%	23%	0.28	0.37		
	Single Indicator: Retail Sales (6m_ret)	71%	69%	58%	22%	0.27	0.37		
Credit Dynamics	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t0)	70%	66%	58%	28%	0.31	0.38		
	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t-1yr)	64%	60%	48%	29%	0.35	0.46		
	MFI Loans to Private Sector (12m_ret) & HP Diff Lag (t-2yr)	60%	57%	43%	31%	0.38	0.50		
	Single Indicator: MFI Loans to Private Sector (12m_ret)	61%	57%	43%	30%	0.37	0.50		
Oil	Crude Oil & HP Diff Lag (t0)	86%	80%	85%	23%	0.21	0.17		
	Crude Oil & HP Diff Lag (t-1yr)	79%	75%	72%	22%	0.24	0.26		
	Crude Oil & HP Diff Lag (t-2yr)	79%	73%	67%	22%	0.25	0.30		
	Single Indicator: Crude Oil	78%	75%	71%	22%	0.24	0.27		
Central Bank Policy	3m EURIBOR (12m_diff) & HP Diff Lag (t0)	70%	75%	65%	16%	0.21	0.30		
	3m EURIBOR (12m_diff) & HP Diff Lag (t-1yr)	66%	72%	58%	16%	0.22	0.35		
	3m EURIBOR (12m_diff) & HP Diff Lag (t-2yr)	68%	69%	61%	23%	0.27	0.35		
	Single Indicator: 3m EURIBOR	63%	59%	42%	27%	0.35	0.50		