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Predicting Recessions in the Euro Area: A Factor Approach

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Recent economic data have pointed to the potential for weaker economic growth in the euro area. This Letter presents a model of recession probabilities using the first five principal components of a range of macroeconomic, financial and global variables as predictors. This model outperforms a yield curve based method, and points to slightly elevated recession risk in the near term.

Introduction

The December 2018 meeting of the Governing Council of the ECB marked the end of the net asset purchases that were undertaken as part of its asset purchase programme (APP). The Governing Council also made clear that it would continue with the reinvestment of maturing securities bought during the APP, in full, "for an extended period of time past the date when it starts raising the key ECB interest rates". Between September 2008 and January 2019, the ECB's balance sheet expanded by 227 per cent as a result of a series of unconventional monetary policy measures adopted in response to the financial crisis and European sovereign debt crisis. The end of net purchases marks both the end of APP and the start of the path towards monetary policy normalisation in the euro area.

Between 2018 Q2 and Q4, there has been a significant amount of negative news concerning the euro area macroeconomy as a whole. Survey data from the IHS Markit Purchasing Manager's Index and the ZEW indicator of economic confidence recorded a marked decline.[1] Negative news from survey data was eventually reflected in realised GDP data. This contrasted with the generally positive economic environment that supported the decision to reduce expansion at the December 2018 Governing Council meeting; growth was above potential in 2016 and 2017, and headline inflation had converged towards target.

However, as net asset purchases ended there was a re-assessment of the balance of risks in the introductory statement of the Governing Council delivered at the accompanying press conference. While the balance of risks was still described on the whole as being *broadly balanced*, there was a shift in language towards balance of risks *moving to the downside* in

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[1]The IHS Markit Purchasing Manager's Index is a survey of market participants, conducted monthly, giving an overall viewpoint of the wellbeing of the economy. The ZEW Indicator is a monthly survey of Germany-based economists regarding current and future economic conditions.

December.[2] This was further adjusted in January 2019 to state that risks *have moved to the downside*.[3] Hence the path of euro area normalisation could face more challenges in comparison to the US experience, where the Fed ended its net asset purchases (from its QE3 programme) in an environment of generally stronger macro data. In this context, it is essential to look at the potential for an elevated probability of shocks to the downside in the euro area.

ECB communications at the time of the December 2018 meeting had emphasised two key arguments as to why overall risks remained broadly balanced, albeit moving to the downside. The first argument is that recent weaknesses are in fact reversions to mean growth performance, relative to previous unusually strong data. Indeed, a recent speech by ECB Chief Economist Peter Praet (Praet, 2018) noted that "[t]he slowdown in euro area economic growth since the start of the year has reflected in no small part a retreat from the strong growth of 2017". It has therefore been argued that the recent data is representative of a shift backwards from high levels seen at the end of last year. Furthermore, survey indicators are still above their long run averages, despite recent falls.

The second argument in ECB communications is that there are positive medium term dynamics at play in domestic sectors, and that recent negative shocks have their origins in volatile external demand factors.[4] This is seen in a speech by ECB President Mario Draghi in November (Draghi, 2018), where he noted that "we still see the overall risks to the growth outlook as broadly balanced, in large part because the underlying drivers of domestic demand remain in place".

In the context of the debate regarding the balance of risks in the euro area, the objective of this Letter is to assess macroeconomic and financial downside risks by quantifying recession probabilities, using simple empirical models.

Recession Probabilities

In order to address our research question, and estimate recession probabilities for the euro area, we estimate two main specifications: a yield curve based approach, and a factor model encompassing a range of financial, global and macroeconomic variables.

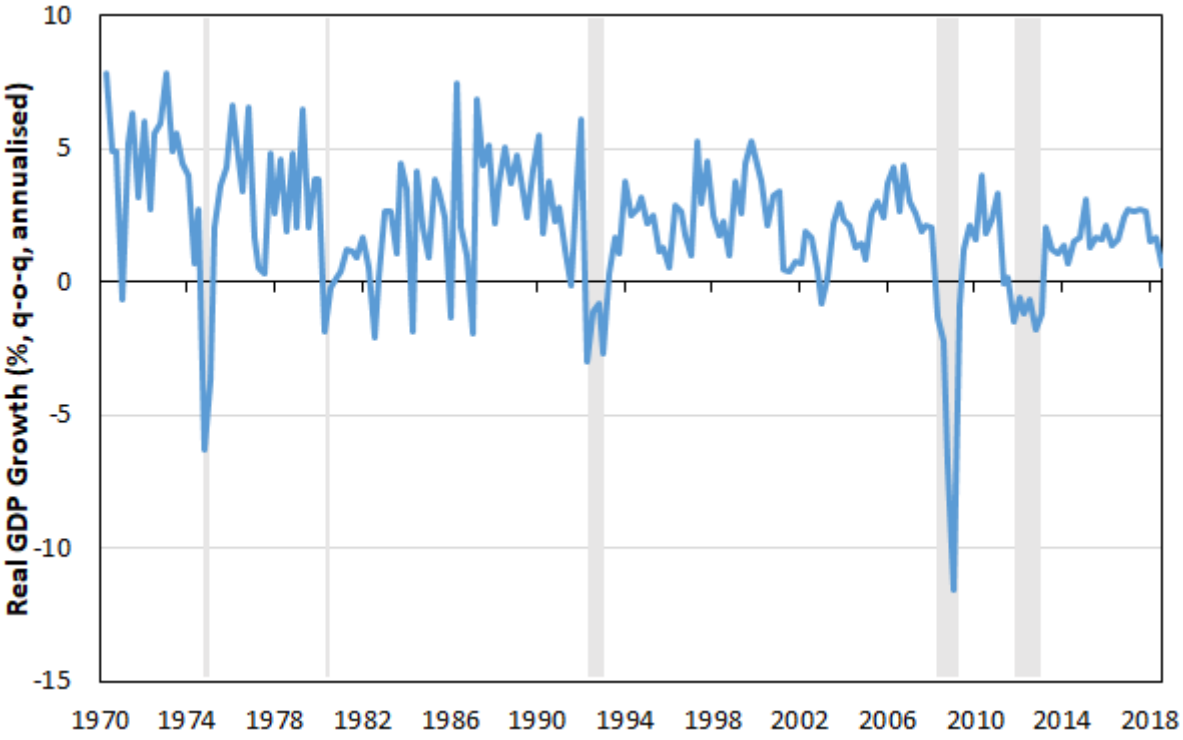
[2] Previous wording at the press conference of the ECB Governing Council was, as seen in the wording of October 2018: "The risks surrounding the euro area growth outlook can still be assessed as broadly balanced. At the same time, risks relating to protectionism, vulnerabilities in emerging markets and financial market volatility remain prominent." This was changed in December 2018 to: "The risks surrounding the euro area growth outlook can still be assessed as broadly balanced. However, the balance of risks is moving to the downside owing to the persistence of uncertainties related to geopolitical factors, the threat of protectionism, vulnerabilities in emerging markets and financial market volatility."

[3] January 2019 wording: "The risks surrounding the euro area growth outlook have moved to the downside on account of the persistence of uncertainties related to geopolitical factors and the threat of protectionism, vulnerabilities in emerging markets and financial market volatility."

[4] These external factors include weakening global trade, risks associated with protectionism, and risks associated with emerging markets.

We focus on recessions due to their long lasting impacts on welfare. A further consideration is the fact that policy constraints currently exist due to the effective lower bound on the policy rates of the ECB, as well as potential limitations on the ability of the ECB to take an increased position in government bond markets, were a new round of APP to be necessary.[5] These policy constraints may limit the ability of the ECB to respond to serious negative shocks. We define a recession period as commencing when quarter on quarter real GDP growth has been negative for two consecutive periods. Recession periods are displayed in Figure 1.[6]

Figure 1: Euro Area Recessions



To evaluate recession probabilities, we combine the recession dates shown in Figure 1 with data on a number of key macroeconomic variables. The data we use are from the euro area wide model data set (Fagan et al., 2001), which we have extended to 2018 Q3. The original data set uses variables which were created by ECB staff using a range of national and international sources. The main value added of the data set is that it creates a long run data series which treats the euro area as a single economy. The model imposes a long run equilibrium consistent with classical economic theory, with short run dynamics being driven by demand. The data are available at a quarterly frequency as far back as 1970 Q1, allowing us to give a thorough overview of long run dynamics in a hypothesised pre-euro economic block.[7] For the purposes of our analysis, we require the longest time series possible, as oth-

[5] Specifically, these constraints follow from limited issuance of bond instruments by member state governments, potential issuance of new debt at lower duration than was previously undertaken, and the self-imposed 33 per cent caps on the positions of the ECB in bond instruments of given horizons, and overall member state bond issuance.

[6] Data from the euro area wide model data set, Fagan et al. (2001).

[7] Unfortunately, a real-time version of the dataset is not available. Given many revisions to macro-data, it

erwise we would have too few observations for our dependent variable of interest, namely recessions.[8]

The first specification we use to evaluate the probability of a recession is:

$$P(RecessionDummy_t = 1) = F_N(\beta_0 + \beta_1 YC_t). \quad (1)$$

We define $RecessionDummy$ as a forward looking variable equal to one if there is a recession in the current quarter, or the following four quarters.[9] We initially assume that recession probabilities can be described as a function of the yield curve. The functional form we choose is the standard normal cumulative distribution function, following the widely used probit approach. The baseline model takes the yield curve (YC), which is defined as the difference between the long run and short run interest rates, as our only explanatory variable. We take these to be the quarterly averages of the three month Euribor rate, and the euro area 10 year government benchmark bond yields. Generally, an inverted yield curve (i.e. a long run rate lower than the short run) serves as a potential warning sign of an upcoming recession, as it is usually interpreted as indicating a future expansion in the monetary policy stance in response to weak macroeconomic data. Key examples of this methodology are seen in works by Estrella and Mishkin (1996) and Favero et al. (2005). Recent work by Johansson and Meldrum (2018) and Stuart and Gerlach (2018) re-examines the usefulness of this approach in the US context.

Many papers have argued for the use of various additional financial and macroeconomic variables in prediction models for recessions. From the perspective of a hypothesised euro area block back to 1970, it is likely preferable to use additional information to the yield curve, due to the weak signalling power of the yield curve alone. This can be seen in the work of Liu and Moench (2014) and Bellégo and Ferrara (2009). Our second specification builds on this insight by adopting factor model of a wide range of key macroeconomic and financial variables as our predictor variables, in order to best summarise the variance in many economic indicators. The closest paper to our study is that of Fendel et al. (2018), who also study the euro area, and also use principal components in several of their probit specifications. However, these authors choose to study a relatively short sample containing only two recessions, whereas our use of the AWM dataset permits investigation of a time-period containing five recessions. Our sample period also allows us to investigate the role of the most recent weak data in 2018 for recession probabilities.

We initially take the first five principal components of potentially informative data from the area wide model data set, alongside other data from FRED and the OECD for inter-

would be of interest to evaluate the performance of our models with respect to real-time data. See Conefrey and Walsh (2018), who develop an indicator using principal components to overcome measurement error issues in an Irish context.

[8] The original data are from the initial 11 euro area countries, however, the series are adjusted for the changing composition over time. A number of annual series are interpolated to make them available on a quarterly basis. The official area wide model series are only updated as far as 2016 Q4. After this, we find matching data series in Datastream, and extend the series in line with the realised growth rate of these series during this time period.

[9] Precisely, this is equal to one if there is a recession in the next five quarters, inclusive of this quarter.

national variables.[10] By studying which variables load onto the principal components with the greatest weight, we are able to give each a broad interpretation. We therefore respectively assign the principal components the names: "Domestic Prices", "Domestic Real Macro", "Commodities and Financial", "Open Economy/Labour", and "Open Economy". Details can be found in Appendix 2, Table 4. These five principal components explain 84 per cent of the variance in the data set.

We then estimate a model similar in fashion to the one specified in Equation (1), using these first five principal components as the predictor variables in place of the yield curve. We therefore estimate the following model by maximum likelihood:

$$P(RecessionDummy_t = 1) = F_N(\beta_0 + \beta_{F,1}PC_{1,t} + \beta_{F,2}PC_{2,t} + \cdots + \beta_{F,5}PC_{5,t}), \quad (2)$$

with $RecessionDummy$ being defined as in (1), and PC_j indicating the jth principal component.

Results

The parameter estimates from the initial probit model across multiple time horizons are shown in Tables 1 and 2.[11] With respect to results from the yield curve model, the coefficient on YC is negative as expected, and is highly significant. As can be seen, the principal components method delivers much better results from a fit perspective, with a persistently higher pseudo-R^2 and AUROC statistics. While many countries may have in effect followed a common monetary policy via fixed exchange rate regimes in the pre-ECB period, this would only have been true to an extent. Thus, the decision to study the pre-ECB period likely renders the yield curve a less-important predictor, relative to its proven effectiveness in the US context. Comparing the pseudo-R^2 of the factor model across horizons, we see the largest value for the case of the shortest horizon model, as we would expect. However, we note that the pseudo-R^2 figures do not decrease overly with horizon, and our models maintain their ability to explain recession probabilities even within four years.

[10] The 40 variables are listed in Appendix 1. All variables are transformed so as to make them stationary, de-meaned and standardised. For robustness we run the same specifications using the first eight principal components, with no change in results.

[11] In each table the AUROC (Area Under Receiver Operating Curve) is reported. This measures how well an estimator can distinguish between two groups (recessions, and the absence of a recession in our case). A reading of 1 suggests perfect classification and 0.5 suggests no information is given by the model.

Table 1: Results of Probit Estimation – multiple time horizons, yield curve model

	One Year	Two Year	Three Year	Four Year
YC_t	-0.292***	-0.318***	-0.253***	-0.244***
	(0.0852)	(0.0806)	(0.0779)	(0.0787)
Constant	-0.674***	-0.281**	-0.0694	0.140
	(0.131)	(0.126)	(0.125)	(0.126)
Observations	195	195	195	195
$Pseudo - R^2$	0.0675	0.0706	0.0422	0.0369
AUROC	0.6155	0.6260	0.6680	0.6631

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

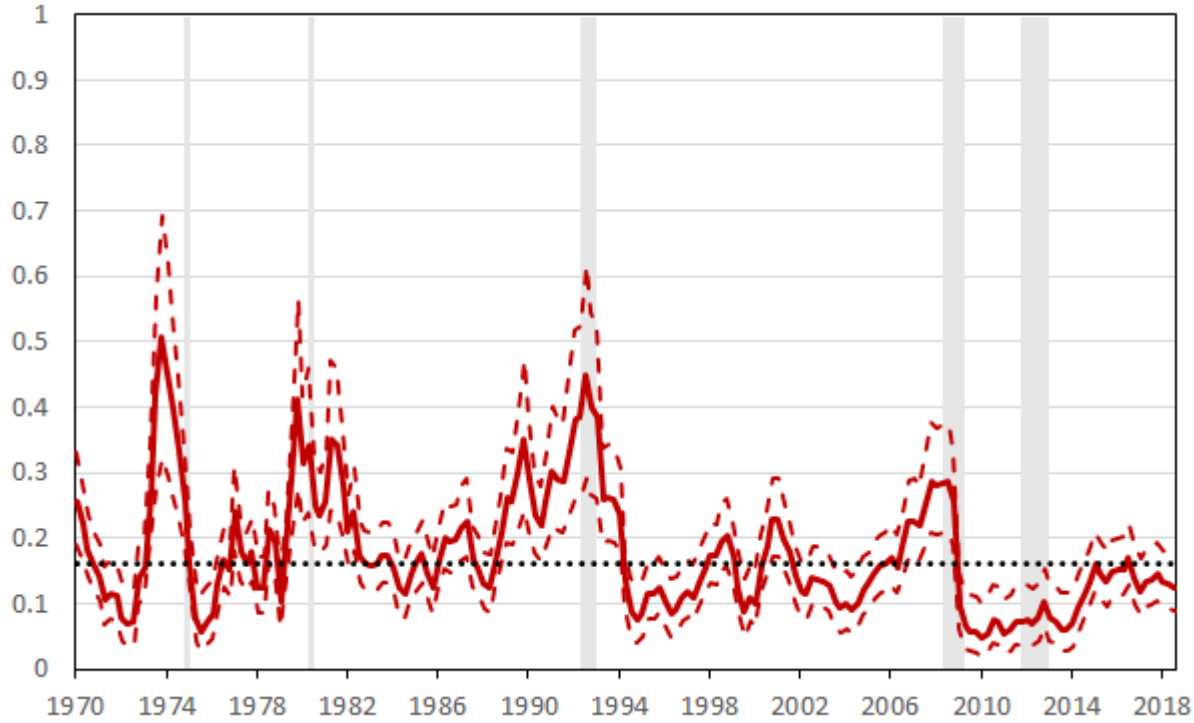
Table 2: Results of Probit Estimation – multiple time horizons, factor model

	One Year	Two Year	Three Year	Four Year
PC1 - Domestic Prices	0.0199	0.0731***	0.0813***	0.122***
	(0.0309)	(0.0277)	(0.0265)	(0.0283)
PC2 - Domestic Real Macro	-0.195***	-0.0816**	-0.0526*	-0.0103
	(0.0406)	(0.0325)	(0.0311)	(0.0305)
PC3 - Commodities and Financial	-0.429***	-0.408***	-0.326***	-0.353***
	(0.0830)	(0.0756)	(0.0683)	(0.0710)
PC4 - Open Economy/Labour	0.0759	0.0217	-0.0450	-0.0600
	(0.0909)	(0.0771)	(0.0714)	(0.0715)
PC5 - Open Economy	0.118	-0.0670	-0.147*	-0.194**
	(0.106)	(0.0812)	(0.0758)	(0.0765)
Constant	-1.265***	-0.682***	-0.344***	-0.0687
	(0.152)	(0.110)	(0.100)	(0.101)
Observations	191	191	191	191
$Pseudo - R^2$	0.3315	0.2151	0.1623	0.1975
AUROC	0.8661	0.7837	0.7478	0.7795

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Therefore the factor model is of more interest for recession prediction, due to its greater in-sample fit. Of note is the varying statistical significance of each of the principal components. The first principal component, mainly consisting of domestic price variables, is insignificant over the one year horizon, but highly significant from two years onwards, with the inverse being true of the coefficient on the principal component named "Domestic Real Macro". One potential explanation of these results is that they reflect the lag with which monetary policy responds to inflationary surprises, in the sense that contractionary policy changes would affect real variables prior to their effect on inflation variables. The principal component representing financial and commodity market variables is highly significant

Figure 2: Predicted Recession Probabilities – Probit Model, 1-Year Horizon



Main Points: The probability of a recession in the next year for the yield curve model is shown above (in bold), with 90% confidence bands in red dashed lines, and the model predicted average is the black dotted horizontal line. Recession probabilities are below their overall mean. As can be seen the model fit is generally low, this yield curve model is outperformed by the factor model. Final data point 2018 Q3.

throughout. The open economy principal components are either insignificant or only significant in the long run.[12]

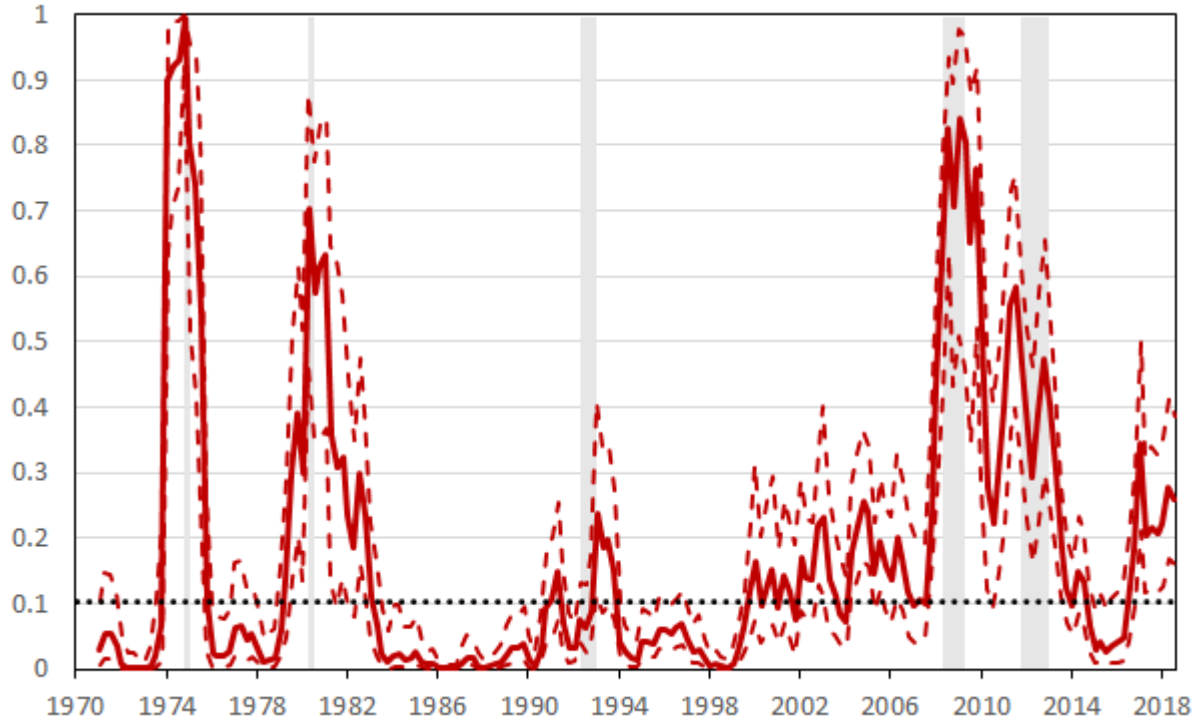
Turning now to the point estimates of predicted probability over time, Figures 2 and 3 show the estimated probability of a recession within a one year horizon.[13] Using a probit model, and a yield curve only approach, we note that in the most recent data the probability of a recession remains below the long term average (though this is insignificant at 90 per cent). Interestingly, for the yield curve approach the predicted probability remains low prior to the recessions in all cases, which reflects the generally poor performance of this model. The predicted probabilities do rise before recessions (with the exception of the sovereign debt crisis), although not to a great extent.

The predicted probability from the factor approach, on the other hand, shows greater volatility, but appears generally to predict all recessions in the sample (with the exception of the 1990's recession). Most noteworthy from the perspective of current policy is a large increase in 2016/2017, before a slight amelioration, and a positive spike afterwards. Over the first three quarters of 2018, results suggest that the probability of a recession in the

[12]Though some factors are insignificant, we prefer to keep all factors in our specifications in any case, so that our model is in principle able respond to all major variations in the underlying data series.

[13]Horizontal lines represent the unconditional mean, as predicted by the model.

Figure 3: Predicted Recession Probabilities – Factor Model, 1-Year Horizon



Main Points: The factor model probabilities are shown in the graph above here (confidence at 90%). As can be seen the model picks up on all recessions but the one in the 1990's, while the rate of false positives is low. Recession probabilities are elevated with respect to the overall mean in the most recent data. Final data point 2018 Q3.

coming year are above the long run average (probabilities are significantly above average from 2017 Q1, at a high degree of significance of 99 per cent). Results are robust to other functional form specifications, including those designed to account for data where there is a low number of observations of positive realisations of the dependent variable (i.e. few cases of recession, with respect to our study).[14]

Table 3 shows point estimates of the probability of a recession for Q1 to Q3 2018 taken from the factor model. As can be seen, there is a marked increase in all measures in Q2, with a slight fall in Q3. Current recession risk remains elevated, and results are robust across forecast horizons.[15]

From a policy perspective it is important to be able to interpret potential reasons for

[14] Results (for both the yield curve and factor models) are robust to logistic regression, complementary log-log, Firth logistic regression and rare events logistic regression.

[15] While recession probabilities are the main focus of our analysis, we also checked the robustness of our results to examining periods of low growth. We examined robustness to changing the dependent variable to an indicator variable taking the value one when growth is on average less than 0.92 per cent for four quarters. The value 0.92 per cent was chosen since it is one standard deviation below average q-o-q annualized GDP growth for the euro area 1999Q1-2007Q4. The overall level of the slowdown probability obviously differs to that of the recession probability. The recent behaviour of the predicted probabilities, in the sense of there being a sharp rise in 2016/2017, a slight amelioration, and a subsequent positive spike is robust to the change in the dependent variable.

increases in realised probabilities. Using the factor model, we compute the marginal contribution of each principal component to the predicted probability for each time period.[16] This is shown in Figure 4 for the post-crisis period. With respect to the most recent dynamics, we can note that the spike in 2016 can be mainly explained by movements in the financial and commodities factor, which itself is largely driven by a spike in the growth of oil prices.

Table 3: Forward Looking Recession Probabilities – Point Estimates from Factor Model

	One Year	Two Year	Three Year	Four Year
2018 Q1	0.22	0.35	0.41	0.49
	[0.13,0.35]	[0.24,0.47]	[0.30,0.53]	[0.37,0.61]
2018 Q2	0.28	0.43	0.49	0.58
	[0.17,0.41]	[0.31,0.56]	[0.37,0.61]	[0.46,0.7]
2018 Q3	0.26	0.41	0.47	0.56
	[0.16,0.39]	[0.29,0.53]	[0.35,0.59]	[0.44,0.67]

90% confidence bands in parenthesis

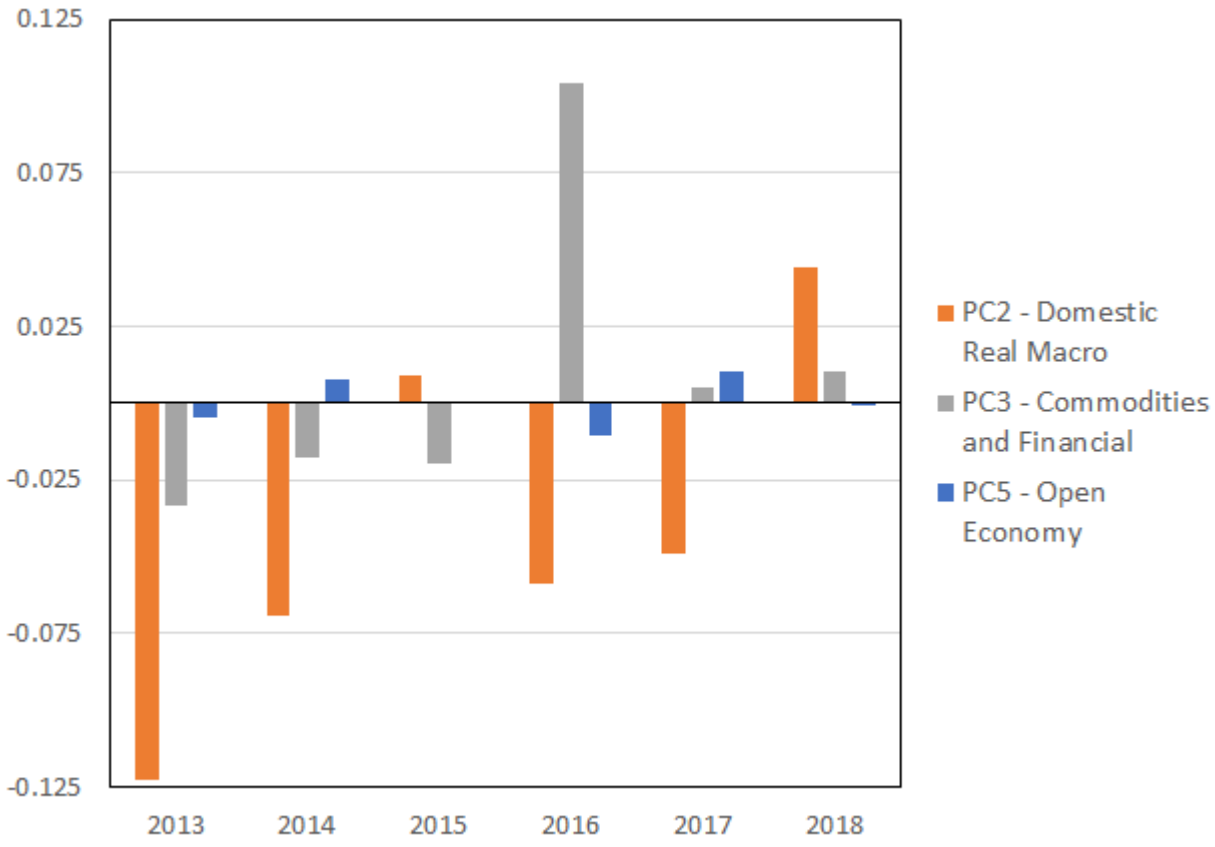
Conclusion

In this Letter, we used principal components of a number of key financial and macroeconomic variables to develop a probit model for predicting recessions, and compared the results to that of a yield curve based methodology. With respect to the most recent data, we found that in the yield curve model, the recession probability remains below the long run average in the short run. However, in the factor model we have seen a recent spike. In general, the factor model appears to outperform the yield curve model in predicting future contractions.

With respect to euro area monetary policy, these results are particularly interesting in the context of normalisation. The ECB recently adjusted its balance of risks assessment in the introductory statement to the January 2019 press conference to acknowledge the fact that risk factors are tilted to the downside, and as such it is important to examine the potential that such risks may lead to a recession. The recent uptick in the probability of a recession according to our various factor probit specifications should thus be of interest to policymakers in the euro area.

[16] The marginal contribution for a given quarter is computed as the predicted value, subtract the predicted value we would achieve if the independent variable of interest was restricted to the value it took in the previous period. Other variables are allowed to evolve freely in the exercise. This permits a measure of the contribution of given variables in our nonlinear setup.

Figure 4: Marginal Contribution of Each Principal Component to Probability of a Recession



Note: Figure displays average marginal contribution of the second, third and fifth principal components to movements in recession probabilities, averaged by year. The contributions of the first and fourth principal component are economically negligible, and are not displayed.

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Appendix 1 – Data used for factor model

Descriptions of data found in the area wide model data set (Fagan et al. (2001)) can be found on the final page of the accompanying documentation `https://eabcn.org/sites/default/files/awm_database_update_18.pdf`.

The variables used, with sources are listed below. All are log differenced (y-o-y), except variables marked with a "*", for which levels are used. The data source is the area wide model, unless otherwise stated.

1. Real GDP at Market Prices
2. General Government Final Consumption Expenditure
3. Gross Fixed Capital Formation
4. Exports of Goods and Services
5. Imports of Goods and Services
6. GDP Deflator
7. General Government Final Consumption Deflator
8. Gross Fixed Capital Formation Deflator
9. Exports of Goods and Services Deflator
10. Imports of Goods and Services Deflator
11. Compensation of Employees
12. Taxes on Production and Imports Less Subsidies
13. HICP (Overall Index)
14. Labour Force
15. Total Employment
16. Total Unemployed
17. Unemployment rate*
18. Short term interest rate*
19. Long term interest rate*
20. Commodity Prices
21. Oil Prices (UK)
22. Non-oil commodity prices
23. Gross Savings Rate*
24. Nominal Effective Exchange Rate
25. UK Real GDP (OECD)
26. UK GDP Deflator (OECD)
27. EU Real GDP (OECD)
28. USA Real GDP (OECD)
29. USA GDP Deflator (OECD)
30. Japan Real GDP (OECD)
31. Japan GDP Deflator (OECD)
32. Swiss Real GDP (OECD)
33. Swiss GDP Deflator (OECD)
34. US CPI Inflation (FRED)
35. US 10 Year Bond Yields* (FRED)
36. US Industrial Production (FRED)
37. US Non Farm Payrolls (FRED)
38. US Producer Price Index (FRED)
39. US 3 Month T-Bills (FRED)
40. US Unemployment Rate (FRED)

Appendix 2 – Principal Components Loadings

Table 4: Principal Components – Ordered by Size of Absolute Value of Component Weights

PC1: Domestic Prices	**PC2: Domestic Real Macro**	**PC3: Commodities and Financial**
Individual Consumption Deflator	European Union Real GDP	Oil Prices
Gross Fixed Capital Consumption Deflator	Imports of Goods and Services	Commodity Prices
HICP Inflation	Gross Fixed Capital Formation	US Producer Price Index
Government Consumption Deflator	GDP at Market Prices	Imports of Goods and Services
GDP Deflator	Exports of goods and services	US 10 Year Bond Yields
US GDP Deflator	US Industrial Production	Non-oil Commodity Prices
Compensation of Employees	US Non Farm Payrolls	10 Year Bond Yields
Japanese Deflator	Swiss Real GDP	US Real GDP

PC4: Open Economy/Labour	**PC5: Open Economy**
Employment	Nominal Effective Exchange Rate
US Industrial Production	US 3 Month Government Bonds
US Unemployment	Swiss Real GDP
Government Consumption	Unemployment Rate
US Real GDP	Government Consumption Expenditure
Gross Fixed Capital Formation	Number of Unemployed
Number of Unemployed	US 10 Year Government Bonds
Nominal Effective Exchange Rate	Savings Rate

Note: Principal components estimated from a dataset containing 40 variables, only the 8 variables with the largest weight (in absolute value) for given factors are displayed.