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KARSTEN STAEHR
LENNO UUSKÜLA

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Forecasting models for non-performing loans in the EU countries

Karsten Staehr and Lenno Uusküla*

Abstract

This paper estimates panel data models that use macroeconomic and macro-financial variables to forecast the ratio of non-performing loans to total loans. The panels consist of either all EU countries or various subgroups, and the time sample is 1997Q4 to 2017Q1. The estimations show that macroeconomic and macro-financial variables have important roles in forecasting non-performing loans. The ratio of non-performing loans exhibits substantial persistence and higher GDP growth, lower inflation and lower debt are robust leading indicators of the ratio of lower non-performing loans. The current account balance and real house prices are important indicators for Western Europe but are less important for Central and Eastern Europe.

JEL Codes: E44, E47, G21

Keywords: non-performing loans, forecasting, financial stability

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* Corresponding author's e-mail address: lenno.uuskyla@eestipank.ee

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Non-technical summary

This paper estimates panel data models that use macroeconomic and macro-financial variables to forecast the ratio of non-performing loans. The forecast horizon in the baseline models is eight quarters, so the lagged dependent variable and the independent variables are included with lags of eight quarters. The analyses consider the sample of essentially all the EU countries, a sample consisting of the Western European EU countries and a sample consisting of the Central and Eastern European EU countries.

The estimations show that the ratio of non-performing loans exhibits substantial persistence, implying that the current ratio is important for forecasting the ratio eight quarters ahead. However, several of the macroeconomic and macro-financial variables also provide important information on the future dynamics of the ratio of non-performing loans. Higher GDP growth, lower inflation and lower debt are robust leading predictors of a lower ratio of non-performing loans in the future. The current account balance and real house prices are important predictors for Western Europe but arguably less so for Central and Eastern Europe. The effect of the unemployment rate differs across the two country groups, possibly reflecting different properties in the business cycles in the two regions.

The analyses show that the specific choice of loan exposure may be of little importance. The forecasting models that used total private loans, household loans and mortgage loans were qualitatively very similar.

The importance of the forecasting horizon is considered in some detail. The existing ratio of non-performing loans becomes less and less important as the forecasting horizon gets longer. The horizon is generally of relatively little importance for the macroeconomic variables, but it is of greater importance for the macro-financial variables, especially total loans. There are some differences between the Western European countries and the Central and Eastern European countries, which in all likelihood are a reflection of the different economic structures and dynamics in the two regions.

The results are robust to numerous changes in the specification and the sample. It is notable however that the removal of total private loans from the specification has a noticeable impact on the estimated coefficients of other macro-financial variables. This shows the key importance of the stock of total loans, or alternative measures of loan exposure, for the future dynamics of non-performing loans.

The analyses confirm the usefulness of key macroeconomic and macro-financial fundamentals in forecasting non-performing loans in panels of EU countries. The findings may thus be useful for surveillance of the banking sector and for assessments of possible threats to financial stability. The analysis reveals however that the forecasting models include more variables and are more robust for the group of Western European countries than they are for the group of Central and Eastern European countries.

Contents

1. Introduction

A high or increasing ratio of non-performing loans in the banking sector may threaten financial stability, impede the intermediation of funds from savers to borrowers, and possibly lower investments with implications for long-term growth. This makes it important to identify the drivers of non-performing loans and how the drivers affect non-performing loans in the future.

This paper estimates panel data models for forecasting the ratio of non-performing loans in the EU countries using macroeconomic and macro-financial variables. One particular focus is on possible differences between the EU countries in Western Europe and those in Central and Eastern Europe. The importance of the length of the forecasting horizon is also considered in some detail. The results of the analysis are of importance both in academic terms and for policy-making.

We find that macroeconomic and macro-financial variables have important roles in predicting future developments in non-performing loans. The ratio of non-performing loans exhibits substantial persistence, implying that the current ratio is important for forecasting the ratio eight quarters ahead. Higher GDP growth, lower inflation and lower debt to GDP are robust predictors of a lower ratio of non-performing loans across all country groups. The current account balance and real house prices are important predictors for the group of Western European countries, but play less pronounced roles in Central and Eastern Europe. The unemployment rate has different signs in predicting non-performing loans for the two country groups, maybe because of different timings and volatility of the cycles. The importance of the forecasting horizon varies across the country groups and the indicators considered; some variables are important for short horizons while others are importance for longer horizons.

Financial stability has been at the forefront of economic analysis and policymaking since the global financial crisis and the ensuring recession. National and international authorities have done much work to monitor developments at the microeconomic and macroeconomic levels to detect signs of imbalances and problems surfacing. They have in their toolboxes various regulatory and direct measures that they may use to strengthen the resilience of the financial sector and to avert future instability.

Many measures designed to ensure financial stability operate with long lags and so they need apposite forecasting of developments in financial markets. Countercyclical capital buffers for instance need time for statistics to be collected, for the decision-making process to be followed, and for the banks to be given enough notice to change their operations, this all totalling perhaps eight quarters or more.

A number of models have been created for use in forecasting future developments in financial markets (Demirgüç-Kunt and Detragiache 2005). Multivariate models are typically preferred for forecasting a continuous variable, and they may comprise either one equation or a system of equations, like in VAR and VECM models. There are both microeconomic and macro-

economic models and both types may consider one or more countries. A tangential literature deals with early warning models that use one or more variables to forecast a discrete event, such as a financial crisis properly defined.

The literature on non-performing loans is limited and largely consists of studies produced after the global financial crisis. This paper contributes to the literature on financial stability by estimating *forecasting models* for non-performing loans. The existing literature typically focuses on explaining the dynamics of non-performing loans, not on forecasting future developments, with the main difference lying in the lag structures used in the different models.

Rinaldi and Sanchis-Arellano (2006) use aggregate or country-level data to estimate panel VECM models on seven euro area members to study the dynamics of non-performing loans in the household sector. They conclude that lower indebtedness and higher house prices are associated with a lower ratio of non-performing loans. Nkusu (2011) uses yearly data for a small panel of advanced countries in a VAR model with only a few variables and finds that higher GDP growth, lower unemployment and higher house prices are associated with a lower ratio of non-performing loans in the short term. Skarica (2014) uses a very short panel from 2007Q3 to 2012Q3 for Central and Eastern European countries, but nevertheless finds that GDP growth, unemployment and inflation have short-term effects on non-performing loans.

There is some evidence for heterogeneity in the relationship between the non-performing loans and macroeconomic aggregates the across countries. Beck et al. (2015) use a comprehensive dataset with annual data for 75 countries over the decade 2000–2010 and seek to uncover some key determinants of non-performing loans. The paper considers contemporaneous and one-year lagged effects and finds that GDP, share prices, the nominal effective exchange rate and the lending interest rate have explanatory power.

Klein (2013) estimates the dynamics of non-performing loans in a panel of Central, Eastern and Southern European countries and finds that banking-sector factors are much less important than the overall macroeconomic conditions both contemporaneously and with a lead time of up to two years. Marki et al. (2014) consider the aggregate ratio of non-performing loans in a panel of 14 EU countries in the pre-crisis years 2000–2008. The number of observations is very small but even so they find that bank-specific variables are important alongside macroeconomic variables, either contemporaneously or lagged by one year.

Some papers use bank-level data. One example is Anastasiou et al. (2016), who use bank data for the EU countries and a limited set of macroeconomic variables not including house prices. They estimate VECM models and consider generalised impulse responses for 10 quarters after a shock in the macroeconomic variables. They find that higher economic growth and higher credit growth lead to lower levels of non-performing loans in the short term. However, none of the variables used in the analysis have any relationship with the ratio of non-performing loans in the longer term, as most of the

effects die out within one and a half years. There appear to be some differences between the dynamics of banks in the core of the euro area and those of banks in the periphery.

Messai and Jouini (2013) study the determinants of non-performing loans in 85 banks in Italy, Spain and Greece. They find that GDP growth, unemployment and the real interest rate are important determinants but so are bank-specific variables such as the profitability of banks and their loan loss reserves. Kjosevski and Petkovski (2016) study the role of bank-specific factors and macroeconomic variables for non-performing loans in a panel of Baltic banks. Their paper finds that macroeconomic variables such as GDP growth, inflation and the private credit stock are important, but so are a number of bank-specific variables.

With its focus on forecasting non-performing loans, this paper complements the growing literature on early warning models for banking distress and financial crises.[1] It is notable that this literature largely ignores the role of non-performing loans; see for example Hollo et al. (2012) or Vermeulen et al. (2015). There are several papers though that use non-performing loans as an early warning indicator for financial distress; see for example Messai and Gallali (2015).

This paper contributes to the literature on financial stability by estimating forecasting models using panel data that seek to identify macroeconomic and macro-financial factors that may be used for forecasting non-performing loans several years into the future. We use country-level data as it is the effects of macroeconomic developments on non-performing loans in the economy overall that are being analysed. The advantage of using data on non-performing loans at the country-level rather than at the bank level is that the ratio expresses the non-performing loans for the entire economy, as it aggregates the non-performing loans by banks and divides them by the aggregate loans of the country.

The models include macroeconomic and macro-financial variables but do not include variables that capture the exposure or performance of the banking sector. This choice is made because including banking sector variables would lead to a lot of observations being lost, especially for the Central and Eastern European EU countries, and also because the literature generally finds that banking sector variables have very little forecasting power in models using aggregate data for the entire economy (Klein 2013; Ghosh 2015).

The focus on EU countries is pertinent because the banking sector is a particularly important intermediator of funds between borrowers and savers in the EU. Besides the estimations for a sample consisting of all the EU countries, we also run estimations to find possible differences in the forecasting model for non-performing loans in Western Europe and in Central and Eastern Europe; in this way this paper extends the discussion of possible sources of heterogeneity in the European Union.

[1] See for example Alessi and Detken (2011), Betz et al. (2013), Babecký et al. (2012), Behn et al. (2013), Bussiere and Fratzcher (2006), and Demirgüç-Kunt and Detragiache (1998).

The baseline estimation results are for a forecasting horizon of eight quarters, meaning that the explanatory variables are lagged by eight quarters. The long forecasting horizon is chosen to take account of the fact that the authorities need sufficient time to react to changes in the macroeconomic environment and introduce measures to improve financial sector stability. The results with different forecasting horizons from four to 12 quarters are also considered.

The main contribution of this paper is the estimation of models explicitly meant for forecasting non-performing loans several years ahead. Unlikely early warning models where the dependent variable is typically discretionary, the non-performing loans variable is a continuous variable and no information is therefore thrown away. The paper is to the best of our knowledge the first express forecasting model for non-performing loans.

The paper also contributes to the literature in other ways. First, we construct relatively long quarterly time series of non-performing loans for all the EU countries by splicing existing series. Second, we use a large number of macroeconomic macro-financial variables in the analysis, including the current account balance, which is seldom used in studies of financial stability and non-performing loans. Third, we consider the projection results for the full panel of EU members, but we also investigate how far Western Europe and Central and Eastern Europe are different. Finally, we investigate in detail the importance of the forecasting horizon, which may matter when supervisory and regulatory measures are constructed.

The rest of the paper is structured as follows. Section 2 discusses the methodology and data used. Section 3 presents the results of the baseline estimations. Section 4 considers the importance of different forecasting horizons for the results. Section 5 presents some robustness checks. Finally, Section 6 concludes.

2. Methodology and data

2.1. Forecasting model

The paper uses macroeconomic panel data for the EU countries to estimate projection or forecasting models with potentially long forecasting horizons. The forecasting model regresses the percentage share of non-performing loans to total loans, NPL, on its lagged value, on the lagged macroeconomic and macro-financial variables, and on the country fixed effects. The fixed effects control for time-invariant and country-specific differences in the mean of the NPL. The baseline specification is given in eq. (1), where i indicates the country, t is the quarter and h is the projection or forecasting horizon, which is the number of quarters of the projection:

$$\mathrm{NPL}_{i,t} = \mu_i + \alpha \mathrm{NPL}_{i,t-h} + \beta X_{i,t-h} + \varepsilon_t, \qquad (1)$$

where the term $\mathrm{NPL}_{i,t}$ is the ratio of non-performing loans to total loans at time t in country i, α is the autoregressive coefficient, μ_i depicts the country

fixed effect, $X_{i,t-h}$ is a vector of macroeconomic and macro-financial variables at time $t-h$, β is the vector of coefficients to be estimated, and ε_t is the error term.

The model specification is inspired by several papers in the literature which estimate panel models with cross-sectional fixed effects. Klein (2013) uses a fixed effects model to estimate the dynamics of NPL in a panel of Central, Eastern and Southern European countries. The setup is also motivated by the early warning literature that seeks to forecast financial crises years before they happen. The long forecasting horizon mitigates possible problems of reverse causality as the dynamics of NPL two or three years ahead are unlikely to affect the contemporaneous values of macroeconomic and macro-financial variables. The approach does nevertheless identify the causal effect of the variables on NPL; the interpretation is instead similar to the local projection in Jorda (2005) where the impulse response functions are estimated using separate models for each horizon.

Our use of country-level data for the non-performing loans stands in contrast to the use of NPL data for individual banks. Aggregating the loan portfolios before calculating the ratio means we get the average effect of macroeconomic factors on non-performing loans in the country, not the average effect on individual banks.

The right-hand variables are macroeconomic and macro-financial variables which have been found to be important in the literature (see Subsection 2.2). The macroeconomic variables comprise GDP growth, the unemployment rate and inflation. The macro-financial variables are total private loans, the current account balance and real house prices. In some estimations we replace total private loans with private housing loans or household loans to test whether the specification of the debt measure matters.

The quarterly data run from 1997Q4 to 2017Q1 but the panel is unbalanced as some observations are missing at the beginning or the end of the sample. The baseline models assume a forecasting horizon of eight quarters, so all the macroeconomic and macro-financial variables are lagged by eight quarters. We estimate the model using least squares with country fixed effects. Besides the baseline specification, we also carry out analyses with different specifications of the forecasting model to ascertain how important the forecasting horizon is.

Our panel consists of all the EU countries except Luxembourg and the United Kingdom, in total 26 countries.[2] Analyses are carried out on the full EU sample and often also on two different groupings of EU countries. The group labelled WEST consists of 15 EU members from Western European, including Cyprus and Malta but excluding Luxembourg and the United Kingdom. The group labelled CEE is the 11 countries from Central and Eastern Europe which joined the EU in 2004, 2007 or 2013. [3] We believe that

[2] Luxembourg is excluded because of its status as a financial centre. The United Kingdom is excluded because it is a financial centre and because data on total private non-financial loans are not available in the ECB database.

[3] The group WEST is made up of Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Malta, Netherlands, Portugal, Spain and Sweden. The group

it is of interest to consider not only the whole EU but also the two groups separately as they may have different economic institutions, different financial sectors and different business cycles (Epstein and Jacoby 2014). The issue is whether these differences cause the forecasting properties of various macroeconomic variables to differ across the country groups.

2.2. Data

The data come from various data sources; Table A1 in Appendix A lists the variables and the data sources. Non-performing loans, NPL, are measured as a percentage share of total loans. The quarterly data from the ECB start in 2003Q1 for many countries, though later for some. We augment the quarterly data with yearly data from the World Bank with the first observation of the non-performing loans at the end of 1997. We use these data wherever they are available and interpolate the missing quarters with cubic splines.

As the baseline models are for forecasts eight quarters ahead, the interpolated data are used for a relatively short period in most cases. Using splines introduces autocorrelation in the short-run dynamics, but here we use the data only for longer term forecasts, and this limits the problem to a minimum.

The final interpolated data on non-performing loans in per cent of total loans, NPL, are shown in Figure 1. It is notable that NPL and its dynamics vary substantially across countries. NPL is generally higher and its variability larger for the CEE countries than for the West European countries, but there are exceptions such as the dramatic increases in NPL in Greece, Cyprus or Ireland after the crises they experienced following the global financial crisis.

The rate of GDP growth depicts the dynamics of household and corporate income, which may be used to service debt obligations. Strong growth generates income and lowers the loan to income ratio for the economy conditional on the dynamics of loans and real estate. There could potentially also be a negative relationship if strong GDP growth is a signal of an economic boom which is unsustainable and lead to financial disruptions in the future.[4]

Unemployment is another measure of the cyclical stance of the economy. Unemployment leads to lower incomes and more uncertainty at the household level and especially in households where more one than member has lost their job.[5]

CEE is made up of Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.

[4] The GDP growth rate has been used in almost every paper estimating non-performing loans, including Anastasiou et al. (2016), Beck et al. (2015), Kjosevski and Petkovski (2016), Klein (2013), Louzis et al. (2012), Makri et al. (2014), Messai and Jouni (2013), Nkusu (2011), and Skarica (2014).

[5] The variable has also been used by Anastasiou et al. (2016), Kjosevski and Petkovski (2016), Klein (2013), Louzis et al. (2012), Makri et al. (2014), Messai and Jouni (2013), and Nkusu (2011).

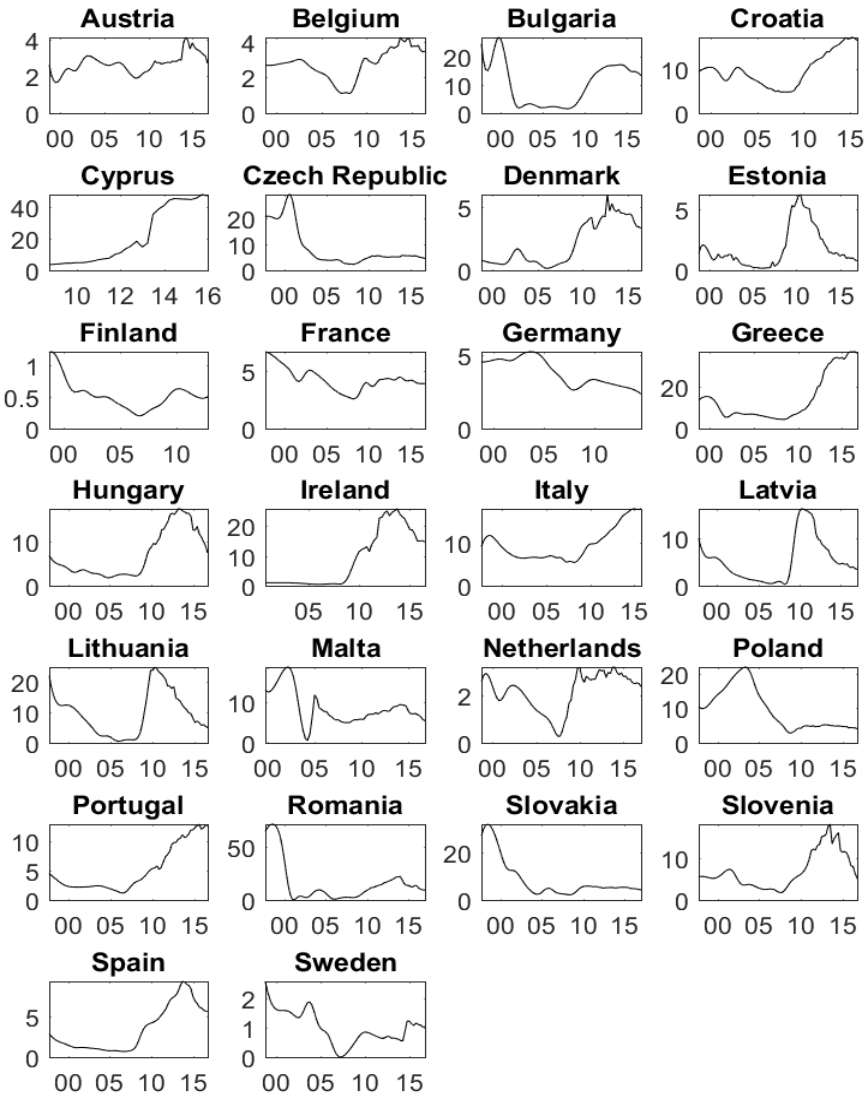

Figure 1: NPL, non-performing loans in per cent of total loans

The final macroeconomic variable is the inflation rate, the year-on-year change in the consumer price index.[6] Higher inflation can measure potential booms in consumption and investment that could cause NPL to rise in future, though it also reduces the real value of debt already accumulated, making debt repayments cheaper.

The macro-financial variable includes total private loans in per cent of GDP. We also show the results when total private loans and mortgages are included in the estimations, though total private loans is the variable with the widest coverage in the sample countries.[7]

[6] The variable has been used in many papers considering NPL developments, including Anastasiou et al. (2016), Kjosevski and Petkovski (2016), Klein (2013), and Makri et al (2014).

[7] Credit variables have been used in many studies including Anastasiou et al. (2016), Klein (2013), Makri et al. (2014) and Messai and Jouni (2013), Rinaldi and Sanchis-Arellano (2006), and Skarica (2014).

House prices may be useful for predicting the future dynamics of NPL. Higher house price growth might reflect a boom and signal future problems, and low house prices may or may not incentivise households to pay loans back in time.[8]

The current account balance is a measure or proxy of international financial flows. A current account deficit means that a country receives capital inflows, while a surplus shows it is a source of outflows. The capital flows may or may not be reflected in the dynamics of lending from the domestic banking sector (Cuestas and Staehr, forthcoming).[9]

3. Baseline results

This section presents the baseline results of the forecasting model with a forecasting horizon of eight quarters for the three different country samples, the full EU, the WEST and the CEE. The models contain the lagged dependent variable, macroeconomic and macro-financial variables, and country fixed effects. Table 1 shows the estimation results of the baseline model for the three country groups, where the debt variable is total private loans in per cent of GDP.

Table 1: Estimation of the baseline forecasting model

	(1.1)	(1.2)	(1.3)
	EU	**WEST**	**CEE**
NPL (-8)	0.670***	0.734***	0.485***
	(0.031)	(0.036)	(0.051)
GDP growth (–8)	–0.297***	–0.259***	–0.211***
	(0.026)	(0.039)	(0.035)
Unemployment (–8)	0.252***	0.417***	–0.381***
	(0.045)	(0.055)	(0.073)
Inflation (–8)	0.585***	0.534***	0.539***
	(0.054)	(0.082)	(0.072)
Total private loans (–8)	0.050***	0.037***	0.140***
	(0.004)	(0.004)	(0.014)
Real house prices (–8)	–0.752	–3.413***	–1.210
	(0.701)	(0.886)	(1.011)
Current account (–8)	–0.175***	–0.245***	0.010
	(0.033)	(0.044)	(0.051)
R^2	0.655	0.757	0.663
Countries	26	15	11
Observations	1287	848	439

Notes: Panel data estimations with country fixed effects. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

[8] The variable has also been used by Nkusu (2011) and Rinaldi and Sanchis-Arellano (2006).

[9] We have not uncovered any other studies using the current account balance to forecast non-performing loans.

The coefficient of the lagged dependent variable is positive and a bit below 0.7 for the full sample, suggesting substantial persistence. Nonetheless, many of the independent variables are also leading variables that help forecast the ratio of non-performing loans eight quarters ahead.

Among the business cycle factors, annual GDP growth being 1 percentage point higher is followed by NPL being 0.3 percentage point lower eight quarters ahead. This result is in line with the shorter-term relationships found in other studies.[10] An increase in unemployment of 1 percentage point is related to a climb of 0.3 percentage point in NPL eight quarters ahead. The sign is as expected and the magnitude of the coefficient is reasonable. Some of the unemployed may have savings that let them keep servicing their debts, while some can rely on relatives and friends, and some may be able to renegotiate their debt or get payments suspended for a period of time.[11] The coefficient of the inflation rate is positive and very precisely estimated. An increase of 1 percentage point in the inflation rate is associated with an increase of 0.6 percentage point in non-performing loans eight quarters ahead, which is arguably a sizeable effect.[12]

The results for the macro-financial variables are somewhat varied. The debt-to-GDP ratio is an important leading variable of NPL, as total private debt-to-GDP being 1 percentage point higher is related to NPL being 0.1 percentage point higher.[13] This tells us that high debt levels can cause repayment problems at a later time. The current account balance also seems to be an important predictor of NPL for the full EU sample. An improvement of 1 percentage point in the current account balance is associated with a decrease in NPL of 0.2 percentage point eight quarters ahead. This may arise because countries that face large capital inflows have difficulties using these additional resources prudently. Finally, house prices are negatively related to NPL but the coefficient is not statistically significant.[14]

It is informative to compare the results for the Western European group of countries and those for the CEE group. The results for WEST in Column (1.2) are very similar to those for the fully pooled EU sample with the exception of real house prices, which appear to be particularly important in the WEST in both economic and statistical terms. The differences are larger for the CEE countries, as shown in Column (1.3). Surprisingly, the sign of

[10] A negative short-term negative relationship is found in Anastasiou et al. (2016), Kjosevski and Petkovski (2016), Louzis et al. (2012), Makri et al. (2014), Messai and Jouni (2013), Nkusu (2011), and Skarica (2014). Beck et al. (2015) find a contemporaneous negative relationship but a positive relationship when GDP growth is included with a one-year lag.

[11] A positive sign for short forecasting horizons has previously been found by Anastasiou et al. (2016), Kjosevski and Petkovski (2016), Klein (2013), Louzis et al. (2012), Makri et al. (2014), Messai and Jouni (2013), and Nkusu (2011).

[12] The sign cannot be due to the denominator of NPL increasing when the inflation rate increases as this denominator effect would have resulted in a negative effect.

[13] A positive sign for the level has also been found by Klein (2013) and Makri et al. (2014).

[14] A negative sign is found between the change of house prices and NPL in the short term by Nkusu (2011) and Rinaldi and Sanchis-Arellano (2006).

the coefficient of the unemployment rate is negative for the CEE, suggesting it perhaps reflects different features of the business cycles in Western Europe and in Central and Eastern Europe. The estimated coefficient of private loans is somewhat larger for the CEE than for the full EU sample and the WEST. Moreover, the coefficients of real house prices and the current account balance are not statistically significant. This may be because both house prices and the current account balance are very volatile in many of the CEE countries (see also Section 5).

The estimations presented in Table 1 used a broad measure of debt, taking total loans in per cent of GDP. This variable is clearly important for forecasting NPL but this raises the question of how other debt measures would perform. We consider household loans and mortgage loans and include them in separate estimations, given the substantial correlation between the different debt measures.

Table 2 shows the results when household loans in per cent of GDP are used instead of total loans. The main change is that the coefficient of mortgage loans is approximately three times as large as that of total loans in Table 1. Including household loans changes little in qualitative terms. The only other consequence of using household loans as a measure of debt is that there are moderate changes in the estimated coefficients of the unemployment rate.

Table 2: Estimation of the baseline forecasting model, household loans

	(2.1)	(2.2)	(2.3)
	EU	**WEST**	**CEE**
NPL (–8)	0.684***	0.743***	0.618***
	(0.030)	(0.035)	(0.049)
GDP growth (–8)	–0.240***	–0.204***	–0.290***
	(0.026)	(0.040)	(0.035)
Unemployment (–8)	0.156***	0.274***	–0.397***
	(0.046)	(0.057)	(0.076)
Inflation (–8)	0.546***	0.493***	0.544***
	(0.052)	(0.080)	(0.076)
Household loans (–8)	0.141***	0.118***	0.151***
	(0.010)	(0.011)	(0.023)
Real house prices (–8)	–0.909	–3.866***	1.151
	(0.682)	(0.882)	(0.023)
Current account (–8)	–0.188***	–0.216***	0.010
	(0.032)	(0.044)	(0.054)
R^2	0.670	0.768	0.618
Countries	26	15	11
Observations	1289	838	451

Notes: Panel data estimations with country fixed effects. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 3 shows the results when mortgage loans in per cent of GDP are used instead of total loans. The results are qualitatively very close to those from the other debt measures. The coefficient of mortgage loans is positive, statistically significant and of broadly the same size for the three country groups considered. The coefficients of real house prices and the current account attain statistical significance in this specification, but only at the 10 per cent level and with a somewhat smaller sample than in the specifications with total debt and household debt.

The baseline estimations in this section give several notable results. The first is that there is substantial persistence of non-performing loans in all three country groups, suggesting that it is important to take the current ratio of non-performing loans into account when forecasting the future ratio. Second, the results for several variables are consistent across the groups of countries. This applies to GDP growth and inflation among the macroeconomic variables and the debt stock among the macro-financial variables. The exact definition of the debt variable does not appear to be very important for its forecasting properties. Third, real house prices and the current account appear to be important for the Western European sample, but not so for the Central and Eastern European sample. Finally, the unemployment rate enters with different signs for the two country groups, arguably reflecting the different dynamics of the unemployment series in the two groups.

Table 3: Estimation of the baseline forecasting model, mortgage loans

	(3.1)	(3.2)	(3.3)
	EU	**WEST**	**CEE**
NPL (–8)	0.683***	0.757***	0.609***
	(0.032)	(0.036)	(0.057)
GDP growth (–8)	–0.309***	–0.253***	–0.312***
	(0.029)	(0.040)	(0.041)
Unemployment (–8)	0.217***	0.342***	–0.370***
	(0.049)	(0.059)	(0.090)
Inflation (–8)	0.513***	0.513***	0.586***
	(0.059)	(0.083)	(0.091)
Mortgage loans (–8)	0.130***	0.107***	0.172***
	(0.013)	(0.013)	(0.043)
Real house prices (–8)	–0.187	–3.552***	2.419*
	(0.779)	(0.916)	(1.246)
Current account (–8)	–0.142***	–0.258***	0.106*
	(0.036)	(0.045)	(0.064)
R^2	0.643	0.755	0.546
Countries	26	15	11
Observations	1235	838	397

Notes: Panel data estimations with country fixed effects. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

4. Forecasting horizon

The results so far have been for a forecasting horizon of eight quarters, as this horizon is highly relevant for policy making. It is helpful however to consider the results for other forecasting horizons, so we have run the baseline estimation in Table 1 for forecasting horizons from four quarters up to 12 quarters. This exercise may provide useful information for policy making that needs forecasts at various horizons, and it may also give some indications of the robustness of the baseline results.

Figure 2 presents the results for the forecast horizons from four to 12 quarters for the full EU sample. The forecast horizon is on the horizontal axis, and the coefficient estimates and the confidence interval computed as ± two standard deviations are on the vertical axis. Unsurprisingly, the coefficient of the lagged dependent variable decreases in the forecasting horizon, and it is around 0.9 when the horizon is four quarters and 0.4 when it is 12 quarters. The coefficients of the macroeconomic variables – GDP growth, unemployment and inflation – remain very stable irrespective of the forecasting horizon. Among the macro-financial variables, total loans and the current account balance appear to increase in importance with the forecasting horizon, suggesting that these variables are particularly useful for longer-term forecasts. The coefficient of the housing price variable does not attain statistical significance whatever the forecasting horizon.

Figure 3 presents the estimated coefficients for different forecast horizons for the sample of EU countries from Western Europe. The results follow closely those for the full EU sample in almost all respects. The main exception is that the coefficient of the house price variable is now statistically significant at all horizons, and it arguably becomes more important as the forecasting horizon is lengthened.

Figure 4 presents the results for the sample of CEE countries. The autoregressive coefficient declines in the forecasting horizon and becomes very small at longer horizons. In the CEE countries the NPL has very little information content for longer-term forecasts. GDP growth similarly appears to become less and less important for NPL forecasts as the horizon is lengthened, while the unemployment rate and CPI inflation retain or even increase their importance as the forecast horizon is extended. Among the macro-financial variables, total loans is the one that is statistically important at any of forecasting horizons considered, a result which is in line with the result for eight quarters shown in Table 1. The coefficient of total loans increases as the forecasting horizon is lengthened.

Figure 2: Estimated coefficients at different forecasting horizons, full EU sample

Figure 3: Estimated coefficients at different forecasting horizons, Western European sample

Figure 4: Estimated coefficients at different forecasting horizons, Central and Eastern European sample

The results in this section provided important insights for the use of macroeconomic and macro-financial variables for medium-term NPL forecasts. The existing value of NPL becomes less and less important as the forecasting horizon gets longer. The horizon is generally of relatively little importance for the macroeconomic variables while it is of greater importance for the macro-financial ones, especially total loans. There are also differences between the groups of countries from Western Europe and Central and Eastern Europe, which can be considered to reflect the different economic structures and dynamics in the two regions.

5. Robustness

This section presents an array of robustness checks focusing on the dynamics of the NPL variable, possible multicollinearity and the country composition of the samples.

The volatility of non-performing loans varies a lot across the sample countries, as does the volatility of most other macroeconomic and macro-financial variables. A way to ascertain whether the regression results could be driven by certain countries that have data exhibiting particularly large volatility is to standardise the data by first demeaning the data series and then dividing them by their standard deviation.[15]

Table 4 shows the results when the non-performing loans variable is standardised but no other variables are. The most noticeable change is that the estimated coefficients of the macroeconomic and macro-financial variables are now very similar across all three country groups. This suggests that the very different variances of the NPL play some role in the results in Sections 3 and 4. The results for the EU and the WEST are largely unchanged in qualitative terms, as, unsurprisingly, the estimated coefficient of the lagged dependent variable declines somewhat. The changes are larger for the CEE countries, where the coefficient of the unemployment rate is still negative and statistically significant, while the coefficients of the real house prices variable and the current account balance now become statistically significant.

The conclusion is that standardising the non-performing loans does not change the results qualitatively, but it leads to more coefficients being statistically significant for the CEE sample. We have also run estimations where NPL are standardised as well as the macroeconomic and macro-financial variables on the right-hand side. The results are comparable to those in Table 4 and so are not reported here.

The next robustness exercise seeks to establish whether individual countries with particularly volatile NPL dynamics affect the results unduly. The strategy is to repeat the baseline estimations from Table 1 but with the volatile countries left out from the samples. Table 5 shows the results with different countries excluded. Column (5.1) shows the results when four countries in Southern Europe are trimmed from the EU sample. The qualitative results are unchanged, though the coefficient of the unemployment rate is lower for the trimmed panel than for the full sample of EU countries.

[15] The early warning literature on financial crises often proposes an indicator for financial distress that is calculated from a set of standardised variables; see for example Vermeulen et al. (2015) and Hollo et al. (2012).

Table 4: Estimation of forecasting models with standardised NPL

	(4.1)	(4.2)	(4.3)
	EU	**WEST**	**CEE**
Standardised NPL (-8)	0.501***	0.490***	0.467***
	(0.026)	(0.031)	(0.051)
GDP growth (-8)	–0.059***	–0.048***	–0.047***
	(0.005)	(0.009)	(0.006)
Unemployment (-8)	0.018**	0.052***	–0.061***
	(0.008)	(0.012)	(0.013)
Inflation (-8)	0.112***	0.116***	0.083***
	(0.011)	(0.019)	(0.012)
Total private loans (-8)	0.013***	0.011***	0.028***
	(0.001)	(0.001)	(0.002)
Real house prices (-8)	–0.442***	–0.635***	–0.641***
	(0.141)	(0.227)	(0.161)
Current account (-8)	–0.029***	–0.037***	–0.031***
	(0.007)	(0.000)	(0.008)
R^2	0.592	0.581	0.726
Countries	26	15	11
Observations	1287	848	439

Notes: Panel data estimations with country fixed effects. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 5: Estimation of forecasting models with countries excluded

	(5.1)	(5.2)	(5.3)
	EU[a]	**WEST**[b]	**CEE**[c]
NPL (-8)	0.596***	0.686***	0.486***
	(0.029)	(0.030)	(0.053)
GDP growth (-8)	–0.241***	–0.106***	–0.195***
	(0.022)	(0.028)	(0.035)
Unemployment (-8)	0.126***	0.207***	–0.289***
	(0.040)	(0.038)	(0.079)
Inflation (-8)	0.529***	0.160***	0.571***
	(0.046)	(0.056)	(0.080)
Total private loans (-8)	0.041***	0.032***	0.130***
	(0.003)	(0.003)	(0.014)
Real house prices (-8)	–0.972*	–2.748***	–1.970*
	(0.580)	(0.610)	(1.017)
Current account (-8)	–0.201***	–0.230***	–0.118**
	(0.030)	(0.031)	(0.058)
R^2	0.618	0.740	0.671
Countries	22	13	9
Observations	1287	848	439

[a] EU excluding Bulgaria, Cyprus, Greece and Romania; [b] WEST excluding Cyprus and Greece; [c] EU excluding Bulgaria and Romania.

Notes: Panel data estimations with country fixed effects. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

Column (5.2) shows the results when Cyprus and Greece are removed from the WEST sample. The coefficients of the macroeconomic variables change quite a lot, though they retain their sign and statistical significance. This result is most likely to be a consequence of the very volatile macroeconomic environment in the two countries excluded. Interestingly, the coefficients of the macro-financial variables do not change much.

The results in Column (5.3) reveal that little changes for the CEE sample when Bulgaria and Romania are excluded. The only notable change is that the coefficient of the current account balance is now negative and statistically significant in the trimmed sample. This bears some resemblance to the findings for the CEE sample, where the coefficient of the current account balance is statistically significant when the standardised NPL is used.

The conclusion from the exclusion of the countries with extreme NPL dynamics is that the baseline model is robust overall to the exclusion of countries with particularly volatile NPL dynamics. It is nevertheless clear that some countries have a substantial influence on the results, suggesting that studies of individual countries may be valuable.

The next robustness check is the exclusion of the macroeconomic and macro-financial variables one at a time. This exercise is pertinent since the variables may be interrelated, which would cause multicollinearity problems. Tables B1–B3 in Appendix B present the results for the EU, WEST and CEE. In each table the first column shows the baseline result from Table 1 and the next columns show the results with the variables removed sequentially.

The results are overall quite robust to the exclusion of individual variables with the exception of the removal of total private loans, which seems to have a noticeable impact on the estimated coefficients of real house prices and the current account balance. This is in all likelihood a reflection of the interconnectedness of financial markets and the three macro-financial variables included in the baseline forecasting model.

The results are otherwise very robust for the Western European sample, while removing individual variables reveals some instability in the Central and Eastern European sample. This applies particularly to the real house price variable and the current account balance variable, a result which is not surprising given that the coefficients of these variables are statistically insignificant in the baseline specification.

The final robustness check is the inclusion of additional variables in the form of year-on-year differences for total private loans and real house prices (not shown). The estimated coefficients of the differenced variables are sensitive to the particular specification but it is notable that the coefficients of the other variables remain largely unchanged, suggesting that the baseline results in Table 1 are reasonably robust.

6. Final comments

This paper estimates panel data models that use macroeconomic and macro-financial variables to forecast the ratio of non-performing loans. The forecast horizon in the baseline models is eight quarters, so the lagged dependent variable and the independent variables are included with lags of eight quarters. The analyses consider the sample of essentially all the EU countries, a sample consisting of the Western European EU countries and a sample consisting of the Central and Eastern European EU countries.

The estimations show that the ratio of non-performing loans exhibits substantial persistence, implying that the current ratio is important for forecasting the ratio eight quarters ahead. However, several of the macroeconomic and macro-financial variables also provide important information on the future dynamics of the ratio of non-performing loans. Higher GDP growth, lower inflation and lower debt are robust leading predictors of a lower ratio of non-performing loans in the future. The current account balance and real house prices are important predictors for Western Europe but arguably less so for Central and Eastern Europe. The effect of the unemployment rate differs across the two country groups, possibly reflecting different properties in the business cycles in the two regions.

The analyses show that the specific choice of loan exposure may be of little importance. The forecasting models that used total private loans, household loans and mortgage loans were qualitatively very similar.

The importance of the forecasting horizon is considered in some detail. The existing ratio of non-performing loans becomes less and less important as the forecasting horizon gets longer. The horizon is generally of relatively little importance for the macroeconomic variables, but it is of greater importance for the macro-financial variables, especially total loans. There are some differences between the Western European countries and the Central and Eastern European countries, which in all likelihood are a reflection of the different economic structures and dynamics in the two regions.

The results are robust to numerous changes in the specification and the sample. It is notable however that the removal of total private loans from the specification has a noticeable impact on the estimated coefficients of other macro-financial variables. This shows the key importance of the stock of total loans, or alternative measures of loan exposure, for the future dynamics of non-performing loans.

The analyses confirm the usefulness of key macroeconomic and macro-financial fundamentals in forecasting non-performing loans in panels of EU countries. The findings may thus be useful for surveillance of the banking sector and for assessments of possible threats to financial stability. The analysis reveals however that the forecasting models include more variables and are more robust for the group of Western European countries than they are for the group of Central and Eastern European countries.

This is the first paper seeking to use macroeconomic and macro-financial variables to forecast non-performing loans several years ahead. There is evi-

dently scope for further work in area to extend and refine the specifications. It may be possible to include additional forecasting variables, such as various kinds of international capital flows. It may be useful consider the inclusion of changes, interaction terms and non-linear transformations of some or all of the forecasting variables. These issues are left for future studies in the area.

References

Alessi, L.; Detken, C. (2011). Quasi real time early warning indicators for costly asset price boom/bust cycles: a role for global liquidity. *European Journal of Political Economy*, 27(3): 520–533.

Anastasiou, D.; Louri, H.; Tsionas, E. G. (2016). Non-performing loans in the euro area: are core-periphery banking markets fragmented? Bank of Greece Working Paper, 219.

Babecký, J.; Havránek, H.; Matějů; J.; Rusnák, M.; Šmídková, K.; Vašíček, B. (2012). Leading indicators of crisis incidence: evidence from developed countries. *Journal of International Money and Finance*, 35: 1–19.

Beck, R.; Jakubik, P.; Piloiu, A. (2015). Key determinants of non-performing loans: new evidence from a global sample. *Open Economies Review*, 26(3): 525–550.

Behn, M.; Detken, K.; Peltonen, T. A.; Schudel, W. (2013). Setting countercyclical capital buffers based on early warning models: would it work? ECB Working Paper, 1604.

Betz, F.; Oprică, S.; Peltonen, T.; Sarlin, P. (2013). Predicting distress in European banks. *Journal of Banking and Finance*, 45(C): 225–241.

Cuestas, J. C.; Staehr, K. (forthcoming). The great leveraging in the European crisis countries. Domestic credit and net foreign liabilities, *Journal of Economic Studies*.

Demirgüç-Kunt, A.; Detragiache, E. (1998). The determinants of banking crises in developing and developed countries. *IMF Staff Papers*, 45(1): 81–109.

Demirgüç-Kunt, A.; Detragiache, E. (2005). Cross-country empirical studies of systemic bank distress: a survey, *National Institute Economic Review*, 192(1): 68–83.

Bussiere, M.; Fratzscher, M. (2006). Towards a new early warning system of financial crises. *Journal of International Money and Finance*, 25(6): 953–973.

Cesa-Bianchi, A.; Cespedes, L. F.; Rebucci, A. (2015). Global liquidity, house prices, and the macroeconomy: evidence from advanced and emerging economies. *Journal of Money, Credit and Banking*, 47(S1): 301–335.

Epstein, R. A.; Jacoby, W. (2014). Eastern enlargement ten years on: transcending the east-west divide? *Journal of Common Market Studies*, 52: 1–16.

Ghosh, A. (2015). Banking-industry specific and regional economic determinants of non-performing loans: evidence from US states. *Journal of Financial Stability*, 20, 93–104.

Hollo, D.; Kremer, M.; Lo Duca, M. (2012). CISS – A composite indicator of systemic stress in the financial system. ECB Working Paper, 1426.

Jorda, O. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review,* 95(1): 161–182.

Kjosevski, J.; Petkovski, M. (2016). Non-performing loans in the Baltic states: determinants and macroeconomic effects. *Baltic Journal of Economics*, 17(2): 25–44.

Klein, N. (2013). Non-performing loans in CESEE: determinants and impact on macroeconomic performance. IMF Working Papers, WP/13/72.

Louzis, D. P., Vouldis, A. T.; Metaxas, V. L. (2012). Macroeconomic and bank-specific determinants of non-performing loans in Greece: A comparative study of mortgage, business and consumer loan portfolios. *Journal of Banking & Finance*, 36(4): 1012–1027.

Makri, V.; Tsagkanos, A.; Bellas, A. (2014). Determinants of non-performing loans: the case of Eurozone. *Panoeconomicus*, 61(2): 193–206.

Messai, A. S.; Jouini, F. (2013). Micro and macro determinants of non-performing loans. *International Journal of Economics and Financial Issues*, 3(4): 852–860.

Messai, A. S.; Gallali, M. I. (2015). Financial leading indicators of banking distress: a micro prudential approach – evidence from Europe. *Asian Social Science*, 11(21): 78–90.

Nkusu, M. (2011). Non-performing loans and macrofinancial vulnerabilities in advanced economies. IMF Working Papers, WP/11/161.

Rinaldi, L.; Sanchis-Arellano, A. (2006). Household debt sustainability: what explains household non-performing loans? An empirical analysis. ECB Working Paper, 570.

Skarica, B. (2014). Determinants of non-performing loans in Central and Eastern European countries. *Financial Theory and Practice*, 38(1): 37–59.

Vermeulen, R.; Hoeberichts, M.; Vašícek, B.; Žigraiová, D.; Šmídková, K.; de Haan, J. (2015). Financial stress indices and financial crises. *Open Economies Review*, 26(3): 383–406.

Yam, J. H. (2016). Impact of macroeconomics and bank specifics on nonperforming loans and banking sustainability performance. *International Journal of Innovation and Applied Studies,* 18(4): 972–989.

Appendix A

Table A1: Data sources

Data	Source
Non-performing loans to total gross loans and advances (NPL), quarterly	ECB
Bank nonperforming loans to total gross loans, yearly	World Bank
Loans to domestic household and NFC private sector	ECB
Loans to households, reported by MFI (stock)	ECB
Mortgage loans as lending to households for house purchase, reported by MFI (stock)	ECB
Real house price index	ECB, Cesa-Bianchi et al. (2015)
CA balance	Eurostat, ECB, IMF IFS
Consumer price index	IMF IFS
Nominal GDP	Eurostat and Datastream
Real GDP	Eurostat and Datastream
Unemployment rate	Eurostat and Datastream

.

Appendix B

Table B1: Estimation of forecasting models with variables omitted, EU

	(B1.1)	(B1.2)	(B1.3)	(B1.4)	(B1.5)	(B1.6)	(B1.7)
NPL (–8)	0.670***	0.652***	0.758***	0.649***	0.673***	0.704***	0.643***
	(0.031)	(0.033)	(0.027)	(0.033)	(0.027)	(0.029)	(0.031)
GDP growth (–8)	–0.297***	..	–0.316***	–0.284***	–0.462***	–0.305***	–0.294***
	(0.026)		(0.026)	(0.027)	(0.026)	(0.026)	(0.026)
Unemployment (–8)	0.252***	0.320***	..	0.221***	0.261***	0.219***	0.239***
	(0.045)	(0.047)		(0.047)	(0.042)	(0.043)	(0.045)
Inflation (–8)	0.585***	0.558***	0.566***	..	0.319***	0.554***	0.679***
	(0.054)	(0.057)	(0.054)		(0.051)	(0.053)	(0.051)
Total private loans (–8)	0.050***	0.069***	0.055***	0.049***	..	0.050***	0.052***
	(0.004)	(0.004)	(0.004)	(0.005)		(0.004)	(0.004)
Real house prices (–8)	–0.752	–1.395*	–1.432**	–1.395*	2.834***	..	0.761
	(0.701)	(0.733)	(0.698)	(0.733)	(0.614)		(0.627)
Current account (–8)	–0.175***	–0.174***	–0.160***	–0.295***	–0.117	–0.164	..
	(0.033)	(0.035)	(0.034)	(0.033)	(0.031)	(0.029)	
R^2	0.655	0.621	0.647	0.623	0.576	0.658	0.647
Countries	26	26	26	26	26	26	26
Observations	1287	1287	1287	1287	1484	1313	1304

Notes: Panel data estimations with country fixed effects. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

Table B2: Estimation of forecasting models with variables omitted, Western European sample

	(B2.1)	(B2.2)	(B2.3)	(B2.4)	(B2.5)	(B2.6)	(B2.7)
NPL (–8)	0.734***	0.708***	0.866***	0.690***	0.621***	0.765***	0.716***
	(0.036)	(0.036)	(0.032)	(0.036)	(0.037)	(0.035)	(0.036)
GDP growth (–8)	–0.259***	..	–0.325***	–0.227***	–0.370***	–0.289***	–0.315***
	(0.039)		(0.040)	(0.040)	(0.040)	(0.039)	(0.038)
Unemployment (-8)	0.417***	0.495***	..	0.343***	0.611***	0.465***	0.358***
	(0.055)	(0.055)		(0.055)	(0.056)	(0.053)	(0.053)
Inflation (–8)	0.534***	0.465***	0.404***	..	0.373***	0.569***	0.546***
	(0.082)	(0.083)	(0.083)		(0.088)	(0.082)	(0.083)
Total private loans (–8)	0.037***	0.047***	0.045***	0.037***	..	0.033***	0.040***
	(0.004)	(0.004)	(0.004)	(0.004)		(0.004)	(0.004)
Real house prices (–8)	–3.413***	–4.387***	–4.807***	–3.842***	–1.277	..	–1.188
	(0.886)	(0.888)	(0.888)	(0.901)	(0.855)		(0.797)
Current account (–8)	–0.245***	–0.324***	–0.165***	–0.253***	–0.234***	–0.179***	..
	(0.044)	(0.044)	(0.044)	(0.045)	(0.045)	(0.040)	
R^2	0.757	0.744	0.740	0.744	0.693	0.757	0.745
Countries	15	15	15	15	15	15	15
Observations	848	848	848	848	882	848	865

Notes: Panel data estimations with country fixed effects. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

Table B3: Estimation of forecasting models with variables omitted, Central and Eastern European sample

	(B3.1)	(B3.2)	(B3.3)	(B3.4)	(B3.5)	(B3.6)	(B3.7)
NPL (–8)	0.485***	0.420***	0.356***	0.486***	0.661***	0.595***	0.486***
	(0.051)	(0.052)	(0.046)	(0.054)	(0.036)	(0.040)	(0.051)
GDP growth (–8)	–0.211***	..	–0.181***	–0.197***	–0.470***	–0.251***	–0.211***
	(0.035)		(0.036)	(0.038)	(0.033)	(0.033)	(0.035)
Unemployment (–8)	–0.381***	–0.311***	..	–0.364***	–0.267***	–0.494***	–0.379***
	(0.073)	(0.074)		(0.077)	(0.063)	(0.067)	(0.071)
Inflation (–8)	0.539***	0.515***	0.526***	..	0.344***	0.480***	0.530***
	(0.072)	(0.076)	(0.075)		(0.065)	(0.070)	(0.060)
Total private loans (–8)	0.140***	0.187***	0.146***	0.165***	..	0.122***	0.140***
	(0.014)	(0.012)	(0.014)	(0.014)		(0.011)	(0.013)
Real house prices (–8)	–1.210	–1.266**	–1.271	–1.417	3.005***	..	–1.299
	(1.011)	(1.035)	(1.043)	(1.073)	(0.825)		(0.906)
Current account (–8)	0.010	0.012	–0.039	–0.208***	–0.006	–0.002	..
	(0.051)	(0.054)	(0.052)	(0.045)	(0.044)	(0.045)	
R^2	0.663	0.634	0.641	0.619	0.562	0.675	0.663
Countries	11	11	11	11	11	11	11
Observations	439	439	439	439	602	465	439

Notes: Panel data estimations with country fixed effects. Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.

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