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$$\frac{n!}{(n-1)!} p^{m-1} (1-p)^{n-m} = p \sum_{\ell=0}^{n-1} \frac{\ell+1}{n} \frac{(n-1)!}{(n-1-\ell)! \ell!} p^{\ell} (1-p)^{n-1-\ell} = p \frac{n-1}{n} \sum_{\ell=0}^{n-1} \left[\frac{\ell}{n-1} + \frac{1}{n-1} \right] \frac{(n-1)!}{(n-1-\ell)! \ell!} p^{\ell} (1-p)^{n-1-\ell} = p^2 \frac{n-1}{n} +$$

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Determinants of Non-Performing Loans: Can National Asset Management Companies Help to Alleviate the Problems?

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Abstract:

Using a novel dataset I examine to what extent the introduction of national Asset Management Companies (AMCs) impacts the effects of bank-specific and macroeconomic determinants of the NPLs ratio for European countries. This study provides evidence on how national AMCs help to alleviate the level of the NPL ratio in countries with high level of non-viable exposures. The results of the dynamic panel data models show that the NPL ratio is lower and less persistent for banks in countries with national AMC since banks are able to clean their balance sheet with lower losses when market prices of NPL are depressed. For countries with national AMC in general the influence of bank-specific factors is lower than during normal conditions. In the case of macroeconomic factors, the results on the size and direction of the impact are mixed. However, these factors remain the key determinants with the unemployment and the lending rate being the leading indicators.

JEL: G21, G28, G32, C23

Keywords: Non-performing loans, Asset Management Companies, credit risk, macroeconomic determinants, bank-specific determinants, dynamic panel data

1. INTRODUCTION

One of the main drivers of the global financial crisis in 2007-2008 was the deterioration of the asset quality of mortgage portfolios and the relaxation of rules when granting loans ((Demyanyk & Hemert, 2007), (Mian & Sufi, 2008), (Keys, et al., 2010), (Doms, et al., 2007)). During this period, the ratio of non-performing loans (NPLs) to gross loans increased dramatically worldwide (See charts in Appendix 8.3). In the United States the average NPL ratio went from one percent in 2006 to six percent in 2010, while in Canada the average ratio tripled in the same period. After the crisis, the average NPL ratio across countries reduced and, in some cases, stabilized with some exceptions in regions experienced additional crisis periods like the European debt crisis.

Currently, there is not unified definition of non-performing loans (NPLs) across countries and banks hindering its comparison. However, when examining definitions across regulators and accounting standards, there is a consensus to consider non-performing a loan that is more than 90 days past due (DPD) or is unlikely to pay for both retail and wholesale customers (Baudino, et al., 2018).

In the last years, regulators worldwide have put a lot of emphasis on the reduction of NPLs releasing rules on management and control. For instance, between 2017 and 2018, the European Central Bank (ECB) Banking Supervision published a guidance that provides a toolkit for banks to manage their NPLs and set the expectations for the provisioning of new NPLs. Other countries reformed their legal frameworks to reduce the workout periods and the net losses (Baudino & Yun, 2017). Whereas, several countries have introduced off-balance-sheet approaches for NPL resolution such as national asset management companies (AMCs) and Special Purpose Vehicles (SPVs) for the reduction of legacy NPLs in banks' balance sheet, being Hungary and Austria some of the most recent cases for AMCs (ESRB, 2017).

In this study, I am interested on identifying bank-specific and macroeconomic determinants of the NPL ratio and examining to what extent the introduction of national AMCs impacts their effect. I start by analyzing the determinants of the NPL ratio in countries part of the Organization for Economic Cooperation and Development (OECD) which later is used as benchmark for the analysis of the introduction of AMCs. I use a novel dataset from 2003 until 2017 with over 3,000 banks. I estimate six empirical models at a bank-level using dynamic panel data techniques. I perform additional analyses to study the possible endogeneity of the macroeconomic factors GDP annual growth rate, unemployment rate and lending rate.

Next, I investigate the effects of the introduction of national AMCs focusing on European countries to ensure completeness of the data on national AMCs for all the countries in the sample. I use the six model specifications with endogeneity considerations from the benchmark analysis. I augment the models by interacting all the independent variables with AMC dummies to directly interpret the impact of the variables

due to AMC. The study provides evidence in favor of the introduction of national AMCs for the reduction of NPL and its persistence.

Although literature studying determinants of NPLs is quite extensive, this is the first study that measures the implications of the introduction of national AMC for NPL deleveraging in countries with high levels of bad loans. Studying the effects of the introduction of national AMCs adds further evidence for the expansion of off-balance-sheet approaches as part of a comprehensive package for the reduction of the NPL stock of affected banks, particularly in countries where there are no clear signs of improvement. By using bank-level models with bank-specific factors resembling bank's profitability, efficiency, risk appetite and diversification, I add further analysis on possible leading indicators of future weakness in the banking system beyond macroeconomic indicators, and I can evaluate how much bank management plays a role on the level of NPLs and how their behavior is affected by the introduction of national AMC.

The methodology can be applied for regulatory top-down stress testing as the linkage of the NPL ratio to macroeconomic indicators naturally allows the generation of forecast across alternative scenarios. It can be further used, by authorities, as a tool to early identify vulnerabilities in the banking system. The outcome of the analysis can serve as a guidance for regulators when developing guidelines for monitoring and risk management and when defining policy actions.

The paper is organized as follows. In Section 2 I provide a summary of the related literature. Section 3 describes the dataset used for the study, its limitations and details about the re-construction of some variables to overcome reporting issues. Section 4 explains the considered factors and the econometric methodology. Section 5 discusses the econometric results and key findings and Section 6 summarizes and concludes.

2. LITERATURE REVIEW

Models linking credit risk parameters to macroeconomic factors have been in the industry and in the literature for already some time (Jakubik & Hermanek, 2001), (Jakubik, 2007), (Simons & Rolwes, 2008), (Foglia, 2009), (Hoggarth, et al., 2005), (Virolainen, 2004), (Carling, et al., 2002), (Sorge, 2004)). For instance, bottom up stress testing exercises require banks to adjust their credit risk models to produce forecast of probability of default and other parameters across alternative scenarios and foresee bank's capital adequacy under extreme events. On the other hand, top down stress testing has also made regulators to develop methodologies to forecast NPLs at a less granular level. Moreover, the introduction of forward-looking provisioning to comply with accounting standards, such as IFRS 9 and CECL, urged banks to develop new frameworks to directly link credit risk parameters to macroeconomic indicators.

Most of the literature studying the determinants of NPLs considers as potential explanatory variables either macroeconomic indicators, bank-specific factors or industry-specific characteristics. The studies that include

macroeconomic factors as determinants of NPLs conclude that these are counter-cyclical ((Barth, et al., 2002)), (Boudriga, et al., 2009), (Louzis, et al., 2010), (Nkusu, 2011), (Skarica, 2013), (Klein, 2013), (Makri, et al., 2014), (Beck, et al., 2015), (Love & Ariss, 2016), (Beaton, et al., 2016), (Espinoza & Prasad, 2010)). The selection of potential macroeconomic drivers relies on the region or country under study. For instance, most of the studies include the growth of gross domestic product (GDP). Other common factors are the unemployment rate ((Klein, 2013), (Nkusu, 2011), (Skarica, 2013), (Louzis, et al., 2010), (Makri, et al., 2014)), inflation ((Klein, 2013), (Skarica, 2013)), market interest rates and lending rates ((Love & Ariss, 2016), (Beck, et al., 2015), (Louzis, et al., 2010)). The literature covering advance and developing economies consider stock prices since this variable tends to be more forward-looking than GDP growth ((Nkusu, 2011), (Beck, et al., 2015)). Other researches introduce alternative country-specific macroeconomic factors such as level of tourism, public debt and exchange rate ((Beaton, et al., 2016), (Beck, et al., 2015), (Makri, et al., 2014)).

When incorporating bank-specific characteristics, the studies tend to focus on management quality and profitability measures ((Espinoza & Prasad, 2010), (Beaton, et al., 2016), (Love & Ariss, 2016), (Klein, 2013), (Louzis, et al., 2010), (Makri, et al., 2014)). These studies assume that banks with bad management will have poor credit scoring systems and policies leading to low profits and high NPLs ((Louzis, et al., 2010), (Beaton, et al., 2016), (Love & Ariss, 2016), (Klein, 2013)). Other literature analyses measures of capitalization to study whether low capitalized banks lead to a deterioration on the credit quality of the bank's loans ((Louzis, et al., 2010), (Love & Ariss, 2016), (Klein, 2013), (Boudriga, et al., 2009) (Makri, et al., 2014)). While others include market share ((Louzis, et al., 2010)) and foreign ownerships as additional determinants of NPLs ((Beaton, et al., 2016)).

When comparing which characteristics are the main drivers of NPLs, Klein (2013) and Louzis et al. (2010) found evidence that macroeconomic factors are stronger than bank-specific; while Makri et al. (2013) reveal that both type of factors have strong impact on the level of NPLs.

This paper contributes to the literature by measuring the effects of the introduction of national AMC on the NPLs ratio using dynamic panel data models at a bank-level and employing a novel dataset that contains financials and performance indicators of over 2,500 European banks. Studies on NPL determinants have limited data samples ((Love & Ariss, 2016), (Klein, 2013), (Louzis, et al., 2010)), and cover one country or region (for example Espinoza (2010) studied the determinants for Gulf Cooperation Council (GCC) countries, Beaton et al. (2016) for Eastern Caribbean Currency Union (ECCU) countries, Love and Ariss (2013) for Egypt, and Louzis et al. (2010) for Greece). On the other hand, studies with a wide coverage of regions or with long history only focus on studying macroeconomic determinants ((Nkusu, 2011), (Boudriga,

et al., 2009), (Beck, et al., 2015)). This analysis can provide evidence on the debate for the introduction of a pan-European AMC for the alleviation of the level of NPLs sitting on banks' balance sheets.

3. DATA

The bank-specific data is from Moody's Analytics BankFocus and the macroeconomic data is collected by Moody's Analytics DataBuffet. The main objective was to have a rich dataset of banks' financials and performance ratios as well as key macroeconomic indicators for many countries and for a reasonable time span. Moody's Analytics BankFocus database stores financial data and performance metrics, including the NPL ratio, of financial institutions in a standardized format. The macroeconomic data comes from the International Monetary Fund (IMF) retrieved from Moody's Analytics DataBuffet historical catalog.

The initial bank-specific database contains more than 650 variables including bank characteristics, balance sheet, profits and losses and financial ratios for 45,311 banks from 199 countries in annual frequency from 1995 until 2016. The data before 2005 consists only of banks from Canada, US and Peru. I limited the study to retail and corporate loans issued by commercial, cooperative, Islamic, saving, and real estate and mortgage banks¹, ending up with a sample of 29,393 banks.

The NPL ratio reported by the banks has 3,095 observations, which are few compared to the number of banks, and ranges from -71.22% to 355% beyond normal boundaries². To overcome this, I leveraged the standardized financial information and calculated the NPL ratio using the formula

$$\text{NPL ratio} = \frac{\text{Impaired, NP loans to customers in thousand USD}}{\text{Gross loans to Customers in thousand USD}} \quad (1)$$

Gross loans to customers include mortgages, consumer and other loans. The use of impaired, NP loans to customers allows to homogenize in some level the definition of NPLs across the considered countries.

By recalculating the NPL ratio using (1), the observations increased to 43,970 and the range adjusted between zero and 1 inclusive according to the expectations. Afterwards, I kept banks with at least 3 consecutive periods of the target variable to allow for dynamic analysis.

The final dataset for the benchmark analysis comprises 4,401 banks from OECD countries with observations from 2003 until 2017. Analysis of different segmentations such as regions and level of country-development did not result in correct model specifications to derive appropriate conclusions and interpretations.³ Part of

¹ Moody's Analytics BankFocus includes information of 18 types of specializations including, among others, banks and holding companies, central banks, clearing and custody institutions, commercial banks, cooperative banks, finance companies, investment banks, security firms, etc.

² The range of the NPL ratio is expected to be between zero and one percent.

³ See full list of countries included in the original dataset in Appendix 8.1.

these can be explained by the divergence on the quality, integrity and accessibility of the data between members and non-members of the OECD. When reducing the sample to European countries, the dataset includes observations from 2005 until 2017 for over 2,500 banks.

4. METHODOLOGY

In this section I describe the process to derive the model specification that will be used to evaluate the persistence of the target variable, study what are the factors that influence its dynamics, determine which type of factors, bank-specific or macroeconomic factors, have the biggest impact, and evaluate to what extent the introduction of national AMCs alters their effect. I start the study by analyzing the determinants of the NPL ratio for OECD countries and use these results as benchmark for the analysis of the introduction of national AMCs in European countries. I begin this section by describing the rationale for selecting the potential bank-specific and macroeconomic explanatory variables and move to explaining the modeling methodology given the data characteristics.

I based the selection of explanatory variables on the economic intuition, the literature overview on NPLs and the data availability. The inclusion of bank-specific factors in the models strives to understand how much bank management plays a role on the level of NPLs by determining the risk profile of the bank's portfolio, and how their decisions could alter the performance of their assets. I adopt common factors used in scoring models for financial institutions more commonly known as bank's CAMEL rating. These factors are directly linked to their risk profile, management quality and strength. The analysis also includes country-specific macroeconomic factors to study whether the economic cycle can have effects on the performance of banks' asset quality. The definition and economic reasoning behind the inclusion of each factor in the empirical analysis is discussed below.

Capital adequacy ratio (CAR): It is defined as the ratio of bank's capital to its own risk and indicates bank's solvency. Under Basel III, banks must hold a minimum of 8% CAR.⁴ This ratio can be a leading indicator in two ways. It can reflect bank's risk policy and level of risk tolerance. Therefore, banks accepting riskier customers in order to increase their customer base would end up with low levels of CAR. Additionally, a reputational effect can occur for banks reporting low capital ratio resulting in a decrease of the demand of high-quality borrowers. Empirical results from Espinoza & Prasad (2010), Makri et al. (2014) and Boudriga, et al. (2009) suggest that CAR has a negative relationship with the NPLs. While Louzis et al. (2010) and Beaton et al. (2016) did not find empirical evidence of this variable determining the NPL ratio.

⁴ Pillar 1 minimum capital requirements cover only credit, market and operational risks. Under Pillar 2, capital requirements are adjusted to the bank's own risk.

Return on average equity (ROAE): This is performance metric measured as the ratio of net income over the average shareholders' equity. Higher ROAE indicates stronger profitability and a signal of better management and ability to monitor, control and mitigate risk. In line with the literature ((Makri et al., 2013), (Love & Ariss, 2016), (Klein, 2013), Louzis et al. (2010)) a negative relationship with NPL ratio is expected.

Return on average assets (ROAA): Also a performance metric, ROAA is the ratio of net income over average assets. Like ROAE, bank's bad performance leads to a deterioration of the asset quality due to the inability of the management to control risk. Beaton et al. (2016) and Louzis et al. (2010) found empirical evidence of a negative relationship with NPL ratio. However, when controlling for the endogeneity of ROAA in the GMM estimation, this relationship did not hold. In contrast, Makri et al. (2013) found it insignificant.

Loan loss reserves to total loans (LLR to TL): This ratio is an estimate of the loss with respect the total loans. It is an asset quality metric and a measure of the bank's risk appetite. If a bank has a high-quality portfolio, this ratio should be low and vice versa. In contrast, banks can also use higher reserves to signal strong performance. Before IFRS 9 and CECL, provisioning was based on actual losses. Therefore, high NPLs were associated with higher reserves. Under the new accounting standards reserves also consider future losses. A negative relationship with NPL is supported by Boudriga et al. (2009). Since the sample finishes before the introduction of the new accounting standards, the analysis does not control for the possible effects.

Non-interest income to operating revenue (Non-II to OR): Non-interest income is composed mainly of fees and commissions while operating revenue is composed of interest income plus non-interest income. This ratio indicates management quality, efficiency and ability to generate other sources of income. A negative relation with NPL ratio is expected as a sign of bank's efficiency and management quality.

Gross loans to customer deposits (LtoD): This ratio indicates bank's liquidity and ability to find sources of funds. If this ratio is less than one, it indicates that the bank's core source of funding are its own deposits. A higher value signs that the bank issues more loans than it can cover with its own deposits. Under liquidity stress period, bank's reputational effect can generate a bank run and lead to a deterioration of the asset's risk profile. Makri et al. (2013) and Beaton et al. (2016) studied whether this ratio determines the NPL ratio and found it insignificant.

Loans to assets (LtoA): The proportion that loans represent of the total assets is an indicator of bank's diversification of income. Consistent with previous findings (Love & Ariss (2016) and Klein (2013)), a positive relationship is expected with the NPL ratio. A higher ratio indicates higher chances of credit risk exposure. However, Beaton et al. (2016) found no significant relationship between loans to assets and the NPL ratio.

Annual growth of gross domestic product (GDPYoY): Main indicator of economic performance, a slow down on the GDP can affect the labor market and induce borrowers to delay payments. Additionally, loan quality

can be thought of as being inversely correlated to origination economic conditions, affecting the composition of the asset quality. There is a consensus in the literature for the negative effect on asset quality ((Espinoza and Prasad, 2010), (Makri et al., 2013), (Love and Ariss, 2016), (Klein, Boudriga et al.,2009), (Nkusu, 2011), (Skarika. 2013), (Beck et al. (2015))). Nevertheless, Boudriga et al. (2009) found it significant only for developing countries.

Inflation (CPI): High inflation can alter the borrower’s ability to meet his/her financial obligations. For developed economies, economic growth is associated with an increase in prices. For another set of countries, for example, Mexico and Argentina, a slowdown in the economic activity usually comes with high inflation. Some studies found positive relationship with the NPL ratio ((Klein, 2013), (Skarika, 2013)) while others found no significant relationship (Makri et al., 2013).

Lending rate (LendingRate): Generally, a positive relationship is associated with high NPL ratio ((Love and Ariss, 2016), (Klein, 2013), (Beck et al., 2015)). An increase on interest rates can negatively affect the timing of the payments, especially for floating loans. Conversely, for fixed term loans with prepayment optionality, a decrease on interest rates incentives customers to look for cheaper alternative sources of funding. Therefore, the NPL ratio can be affected by the change on the bank’s balance sheet composition due to customers switching to other products or banks.

Unemployment rate (U): An increase on unemployment rate can directly decrease customer’s ability to meet its financial obligations ((Makri et al., 2013), (Klein, 2013), (Nkusu, 2011), (Skarika,2013)). Lagged values are expected to have higher effect than contemporaneous values due to labor market rigidities.

Annual growth of stock prices (StockYoY growth): A drop in stock prices can affect the economy and raise the level of NPLs not only via the DPD criteria but also via qualitative criteria particularly for wholesale borrowers. Therefore, as shown by Espinoza and Prasad (2010), Nkusu (2011) and Beck et al. (2015), I expect a negative relation with the NPL ratio.

Table 1 presents the summary statistics of the NPL ratio and its potential determinants.

Table 1. Summary statistics for OCDE country members

Variable	N	Min	Median	Mean	Max
NPL ratio	24,821	0.00	2.79	5.47	100.00
CAR	19,146	0.36	16.43	17.97	98.96
ROAE	24,868	-148.95	3.86	4.26	121.33
ROAA	25,073	-49.73	0.29	0.39	37.66
LLR to TL	24,772	-13.22	1.39	2.88	100.00
NII to OR	25,062	-863.30	28.16	28.94	903.74
LtoA	25,074	0.00	62.76	60.77	99.87
LtoD	24,334	0.00	87.18	96.36	991.52
GDPYoY	29,219	-9.13	1.57	1.48	25.01
Inflation	29,219	-1.64	1.14	1.20	11.14
LendingRate	28,839	0.88	2.69	2.76	10.06

U	29,219	2.84	5.27	6.72	27.48
StockYoY	23,071	-51.88	8.63	7.71	55.80

The sample presents diversity in the level of NPL ratio across countries. For instance, Greece and Latvia have the highest NPL ratio on average, while for Australia, Canada and New Zealand the average NPL ratio is below one percent. The majority of countries present an improvement on the ratio from 2014 driven by either a reduction on the level of NPLs with an increase in volumes of loans or decrease of volumes in slower pace than the NPLs levels.

The sample contains banks with CAR below the 8% minimum required under Basel II, with the highest percentage observed during the peak of the global financial crisis. Looking at the time dynamics of the CAR against the NPL, there is a clear negative relationship but few countries such as Canada, Chile, Finland and Italy present a positive relationship. In general, in most countries, CAR improved or stabilized from 2014 except from Japan and Israel. In line with the NPL ratios, the countries with the lowest ratio of reserves to gross loans are Australia, Finland and New Zealand, while Latvia and Greece report the highest reserves. Negative reserves represent accumulated losses and are observed in seven banks from Italy and Germany.

Annual growth of GDP and stock prices range from positive to negative values showing the negative effects of the global financial crisis and the European government debt crisis. The countries with the highest unemployment rate are Spain and Greece with its peak between 2012 and 2015. Turkey, Mexico and Hungary are the countries with periods of inflation above five percent; while Chile, Mexico, Australia and Hungary present the highest lending rates in the sample.

Table 2 summarizes the set of potential explanatory variables and expected relationship with the NPL ratio.

Table 2. Summary of potential explanatory variables and expected signs

Type	Variable	Expected Sign
Bank-specific	CAR	Positive/ Negative
	ROAE	Negative
	ROAA	Negative
	LLR to TL	Positive/ Negative
	Non-II to OR	Negative
	LtoA	Positive
	LtoD	Positive
Macroeconomic	GDPYoY	Negative
	StockYoY	Negative
	U	Positive
	CPI	Positive/ Negative
	Lending Rate	Positive/ Negative

I performed correlation analysis to detect potential multicollinearity. Appendix 8.4 presents the correlation matrix of the NPL ratio and its potential determinants. Loan loss reserves to total loans ratio is the variable

with the highest correlation with the NPL ratio since reserves are derived by the amount of impaired/non-performing loans. Subsequently, unemployment rate is second highest correlated with the NPL ratio followed by the ROAE, ROAA and GDP growth. The variables with the lowest correlation with the target variable are the annual growth of the Stock price and the CAR. To avoid potential multicollinearity between ROAE and ROAA, I kept in the set of potential drivers the one with the highest correlation with the NPL ratio which is the ROAA.⁵

Furthermore, I made single factor models for each of the potential explanatory variables using the NPL ratio as their explanatory variable to analyze the direction of the effects. The analysis indicates possible bi-directional causality for all the bank-specific variables and the macroeconomic factors GDP annual growth rate, unemployment rate and lending rate.

For estimating non-performing loans, I used the Arellano-Bond and Arellano-Bover/Blundel Bond dynamic panel estimators. These estimators are designed for datasets with 1) small time period and many panels, 2) linear functional relationship, 3) dependency of the target variable on its past realizations, 4) not strictly exogenous factors⁶, 5) fixed individual effects and 6) heteroskedasticity and autocorrelation within individuals but not across them (Roodman, 2009). Including lag values of the target variable in the model introduces correlation that biases standard panel-data estimators (Gutierrez & El-Khattabi, 2017).

Dynamic panel modeling technique is suitable for the final dataset since it has small time period and large number of panels. In addition, previous studies on NPL ratios found evidence of the presence of persistence due to the accumulation of NPLs on bank's balance sheet (Espinoza & Prasad, 2010), (Beaton, et al., 2016), (Love & Ariss, 2016), (Klein, 2013), (Nkusu, 2011), (Beck, et al., 2015), (Louzis, et al., 2010), (Makri, et al., 2014)). For instance, bank's lending standards and policies for the derecognition and write-off of NPLs can influence the volumes of these assets on the balance sheet. Finally, given the importance of the banking system in the economy, the assumption of exogeneity in the model when considering both macroeconomic indicators and bank characteristics is not feasible.

The Arellano-Bond estimator (Arellano & Bond, 1991), also known as difference GMM, consists on differentiating all the regressors using Generalized Method of Moments (GMM). The Arellano-Bond estimation uses all the available lagged values of the dependent variable plus lagged values of the exogenous regressors as instruments. Whereas Arellano-Bover/Blundel Bond estimator or system GMM first differentiates the instruments and jointly estimates the system of equations consisting of the level and transformed equations.

⁵ ROAA and ROAE have correlation of 85% and both are performance metrics.

⁶ Past values and current values of the explanatory variables are correlated with residuals.

The Arellano-Bond estimator is a consistent estimator as observations approach infinity. However, it has poor finite sample properties when series are highly persistent. By construction, the residuals of the differenced equation should possess serial correlation, but if the assumption of serial independence in the original errors is warranted, the differenced residuals should not exhibit significant AR(2) behavior. System GMM adds extra conditions allowing the lag of the first difference to enter as instruments in the level equation correcting any bias from difference GMM.

Difference GMM might be subject to large finite sample bias when instruments are weak. Therefore, GMM estimators should be compared to pooled OLS and fixed effects estimators to determine its appropriateness as established by Bond (2001). Pooled OLS estimate, $\hat{\alpha}^{POLS}$, is the upper bound while the fixed effects estimate, $\hat{\alpha}^{FE}$, is the lower bound. As a rule of thumb, system GMM should be selected when difference GMM estimator, $\hat{\alpha}^{GMM}$, is close or below to $\hat{\alpha}^{FE}$, since GMM estimator is downward biased because of weak instrumentation, while difference GMM should be selected when $\hat{\alpha}^{GMM}$ is closer to $\hat{\alpha}^{POLS}$.

For both analyses, I start by estimating the dynamic model using pooled OLS and fixed effects to obtain the upper and lower bounds for the difference GMM estimator and determine its appropriateness. Appendix 8.5 summarizes the six considered model specifications to account for potential multicollinearity. Models 1 to 3 include all potential bank-specific variables but loans to deposit ratio. Model 1 uses entire potential macroeconomic determinants, Model 2 excludes the annual growth of stock prices and Model 3 excludes the annual growth of GDP. Models 4 to 6 follow the same specifications as Models 1 to 3 replacing the loan to asset ratio with the loans to deposit ratio.

5. EMPIRICAL RESULTS

The study focuses on identifying bank-specific and macroeconomic determinants of the NPL ratio and examining to what extent the introduction of national AMCs impacts their effect. First, I analyze the determinants of the NPL ratio in OECD countries, evaluate the persistence of the NPL ratio and distinguish what factors, bank-specific or macroeconomic, have the biggest impact. Next, I use this analysis as benchmark and augment the models to evaluate the effects of the introduction of national AMCs in European countries.

5.1. Benchmark Analysis: Determinants of the NPL ratio for OECD countries

In the benchmark analysis, I evaluate the persistence of the NPL ratio and distinguish the impact of bank-specific and macroeconomic factors. As a starting point, I used two-step GMM for six models with the lag of the NPL ratio and bank-specific variables as endogenous. Given the potential bi-directional causality of the annual growth rate of GDP, unemployment rate and lending rate to the NPL ratio, these variables were treated as endogenous one-step at a time and concluded their appropriateness by analyzing the performance of the Hansen test. Only Models 1 and 2, which contain the loans to asset ratio in the set of explanatory

variables, had an improvement on the Hansen test once the annual growth of GDP is treated as endogenous.⁷ Therefore, this confirms the need of the annual growth of GDP as instrument for these models. Appendix 8.6 presents the results of the Arellano-Bond estimations.

The results across models are similar in the number of statistically significant factors, direction of the effects and level of the coefficient estimates. For all the models, the first lag of the NPL ratio is statistically significant and with positive sign confirming the high level of persistence of the NPL ratio and the need of a dynamic model. The number of instruments is lower than the number of groups (≈ 300 vs $> 3,000$) indicating that there is no problem of instruments proliferation. Moreover, the Hansen test for joint validity of the instruments suggests that the instruments are appropriate. However, the p-values of the test for Models 1, 3, and 6, when the lag of the NPL ratio and bank-specific variables are endogenous, sign potential troubles. Likewise, Models 3 to 6 when the annual growth of GDP is endogenous have the same conclusion. As an alternative, the use of collapse can be used to reduce the size of the instruments matrix and prevent the overestimation bias in small samples when the number of instruments is close to the number of observations (Roodman, 2009). Since the number of instruments is far from the number of groups, the use of collapse is unnecessary. Lastly, the Arellano-bond autocorrelation and serial correlation test of the error term rejects the null hypothesis of no first-order serial correlation and does not reject the null hypothesis of no second-order serial correlation. Analysis of the empirical results are thus from Models 4 and 5 from the first exercise and Models 1 and 2 from the second exercise.

The lag estimate of the CAR is significant and negative in line with the literature ((Espinoza and Prasad, 2010), (Makri et al., 2013), (Boudriga et al., 2009)). Banks with low quality loans tend to have lower capital ratios because of higher risk weights. Therefore, there can be a reputational effect to banks reporting low capital ratio lowering the demand from high quality credit.

In line with the literature (Louzis et al. (2010), Love and Ariss (2013), Makri et al. (2013) and Klein (2013)) and expectations, the effect of the performance metric ROAE, lagged and contemporaneous, on the NPL ratio is negative and significant with the latter having the biggest effect. These results indicate that bad management will tend to have lower quality portfolios. Moreover, past low profitability can lead banks to take riskier positions by lending to lower quality borrowers in order to improve banks' performance.

Surprisingly, the coefficient estimates of the lag of non-interest income to operating revenues is significant and positive. However, this effect is small suggesting that management ability to generate other sources of income

⁷ Estimation results for all tested specifications including macroeconomic variables as endogenous are available upon request.

from fees and commissions can drive to a deterioration of the quality of the portfolio by focusing on profitability rather than on the quality of credit risk underwriting and monitoring.

Coefficient estimates of the contemporaneous value of loans to assets are statistically significant. However, the direction of the effect is opposite of the expectation and the literature ((Love & Ariss, 2016) and (Klein, 2013)) for all models, indicating that an increase in the percentage of loans with respect the total assets would lower the NPL ratio. One possible explanation of this result is that banks would diversify the risk profile of their portfolios when seeking to increase the size of their loans. In contrast, the coefficient estimates for the lagged values are in line with expectations reflecting possible inability of the loan granting models to identify potential risky customers.

Models including loans to deposit ratio have negative and statistically significant correlation with the NPL ratio for the lagged and contemporaneous value. This suggests that banks that diversify their source of funding are inclined to have higher quality assets. However, they might be highly affected during periods of liquidity stress.

For all the considered macroeconomic factors, the direction of the results is robust across the model specifications. An increase on inflation leads to a drop on NPL ratio indicating that the rise in prices is associated with economic boost and improvement in consumer's ability to pay their debts. Conversely, the lagged value has positive effect on NPLs which is in line with the literature and results from Klein (2013) and Skarika (2013).

The direction of the effect of a change on the annual growth of GDP and lagged value of unemployment rate are consistent with the expectations and the literature ((Espinoza and Prasad, 2010), (Makri et al.,2013), (Love and Ariss, 2016), (Klein, 2013), (Boudriga et al., 2009), (Nkusu, 2011), (Skarika, 2013), (Beck et al., 2015)). A drop on the annual GDP growth has an adverse impact on NPLs, contemporaneously and lagged. Contrary, economic development boosts household's purchasing power and ability to pay while also, bank's credit risk policy tightens providing loans to customers with higher credit score. Likewise, an increase on unemployment rate a year earlier affects household's income and exacerbates the late payment of their credit. Moreover, current values of unemployment rate are statistically insignificant across models suggesting that the unemployment rate has delay effects to consumer's ability to pay their credit possibly caused by the existence of unemployment compensations and insurance.

Like the results from Love and Ariss (2016), Klein (2013) and Beck et al. (2015) a rise in the lending rate from previous year increases the NPL ratio. This result can be driven mainly by a rise of debt servicing costs for customers with floating interest rate. However, the study does not distinguish between fixed rate and floating loans.

Lastly, a contemporaneous drop on the stock prices significantly increases the NPL ratio. Though, the size of the effect is small compared to other macroeconomic factors due to the fact that the dependent variable is composed of loans to customers such as mortgages and consumer. Therefore, a bigger effect would be expected for corporate loans.

Furthermore, based on the size of the coefficient estimates across the tested drivers, the macroeconomic factors have the biggest impact on the NPL ratio, consistent with the results from Klein (2013) and Louzis et al. (2010), being the lag of the lending rate and unemployment rate the key drivers of the dependent variable.

After comparing the results of the relevant models⁸, I conclude that Model 1 from the 2-step GMM with the lag of the NPL ratio, bank-specific variables and the annual growth of GDP treated as endogenous appears to be the most parsimonious model consistent with the economic theory and historical analysis.

5.1. Effects of National AMCs on the NPL ratio in Europe

In this section, I extend the study to measure the effects of the introduction of national AMCs to the determinants of the NPL ratio. Several countries have established national AMCs to alleviate the level of NPLs from bank's balance sheet in an environment of depressed market prices. Elevated levels of NPLs have adverse effects in the economy: they reduce capital and management attention from the core banking activities, produce uncertainty on the asset valuation, and decrease bank's profitability and ability to supply new loans.

I investigate what extent the existence of national AMCs modifies the impact of the factors on determining the NPL ratio. I limit the study to European countries since it is very difficult to find complete information of the existence of national AMCs and the year of the introduction for all the countries in the original modeling sample. Appendix 8.7 lists the European countries with national AMC and the year of creation being Hungary and Austria the most recent cases. Usually, these AMCs were introduced to tackle the consequences of crises from rapid credit expansion or real state booms rather than slow economic activity. The dataset restricted to European banks goes from 2005 until 2017 and contains over 2,500 banks.

I use the previous model specifications and interact all the explanatory variables with a dummy variable to capture the difference between the determinants of the NPL ratio for banks in countries with and without national AMC. This approach allows to easily interpret these extra coefficient estimates as the change of the impact due to AMC.

Appendix 8.8 presents the estimation results. I used two-step GMM with the lag of the NPL ratio and bank-specific variables as endogenous. In addition, I account for potential endogeneity of the macroeconomic

⁸ Models 4 and 5 with the lag of the NPL ratio and the bank-specific variables treated as endogenous, and Models 1 and 2 with the lag of the NPL ratio, bank-specific variables and the annual growth of GDP treated as endogenous.

indicators. Model specifications 3 and 6 with either the inflation or the lending rate treated as endogenous and Model 4 with the inflation and the GDP annual growth rate resulted with correct model conditions to derive analysis.⁹

The study provides evidence that the introduction of AMC lessens the level of the NPL ratio. The estimation results show that the NPL ratio is lower and less persistent for banks in countries with national AMC since banks are able to clean their balance sheet even with lower losses when market prices of NPL are depressed.

The key bank-specific determinants are ROAE and CAR. However, the estimation results suggest that when existing national AMCs, in general, the influence of bank-specific factors is lower. That is, AMCs facilitate the reduction of legacy NPLs at a lower cost improving bank's balance sheet and profitability and allowing bank's management to focus their attention in core banking activities.

In contrast, when including the AMC interaction, the direction of the effect of the ratio of loans to assets and loans to deposits is positive and in line with the literature ((Love & Ariss, 2016) and (Klein, 2013)). Hence, when markets have national AMC, less diversification of assets and sources of funding decreases the NPL ratio.

The macroeconomic factors remain the key determinants with the unemployment and the lending rate being the leading indicators. However, there are mixed results on the size and direction of the impact. For instance, the sign of the effect of the stock prices depends on the existence of the national AMC. When including the annual GDP growth in the model (Column 6 in Appendix 8.8, model 4), the impact of the contemporaneous value does not distinguish between countries with and without national AMCs. Furthermore, the lag of the annual GDP growth only affects banks with access to AMC. Banks in countries with national AMC have higher impact of inflation, unemployment and the lag of the lending rate while the impact of the lag of inflation and unemployment are lower.

5.2. Robustness

When studying the determinants for OECD countries, I tested six different specifications in two exercises using dynamic panel models, as described above. The results are robust across all model specifications. I performed an additional analysis with the sample starting from 2010, after the peak of the financial crisis. In general, the magnitude, direction and level of significance of all coefficient estimates do not present substantial

⁹ For all the models, the first lag of the NPL ratio is statistically significant and within the boundaries, there is no problem of instruments proliferation, the Hansen test suggests that the instruments are appropriate, and the Arellano-bond test indicates no first-order serial correlation and no second-order serial correlation.

changes. I obtained similar findings while performing the same analysis when studying the effects of the introduction of national AMC in Europe.

I should point out that the sample might not be representative for the selected countries. However, since the intention of the study is to identify bank-level factors that drive NPL ratios, both bank-specific and macroeconomic, this database allows to cover a broad range of banks and therefore, it is suitable for the analysis.

6. CONCLUSION

The study examines to what extent the introduction of national AMC impacts the size and direction of the effects of bank-specific and macroeconomic determinants of the NPLs ratio for European countries.

The study starts by analyzing the determinants of NPL ratios for banks in OCDE countries, which is later used as benchmark for evaluating the effect of the introduction of AMC. The benchmark analysis considers bank-specific and macroeconomic factors as potential explanatory variables of the NPL ratio. I develop a model at a bank-level using dynamic panel data models to evaluate the persistence of the NPL ratio, study what are the factors that influence its dynamics and determine which type of factors, either bank-specific or macroeconomic, have the biggest impact. The inclusion of bank-specific factors in the analysis seeks to understand how much bank management plays a role on the level of NPLs. In one hand, bank's management decides the risk profile of the asset portfolio when setting the budget plan, risk appetite and credit risk policy. On the other hand, bad management can damage bank's performance and reputation discouraging good quality customers to apply for loans. Macroeconomic factors are also included in the model to analyze whether the economic cycle can alter the performance of the bank's assets.

The econometric analysis for OECD countries suggests that the lag of the NPL ratio, all the considered bank-specific variables and the annual growth of GDP are endogenous. These results confirm the high level of persistence on the NPL ratio due to the accumulation of NPLs. The macroeconomic factors have the biggest impact on the NPL ratio. Main macroeconomic indicators driving the NPL ratio for consumer loans are the lag of the lending rate and unemployment rate. I find evidence of cyclicity of the NPL ratio. A downturn on the economy negatively affects the asset quality of banks. Moreover, the study suggests that higher lending rate a year ago increases the level of NPLs. This result can be driven by floating interest rate loans given a rise of debt servicing costs. Bank-level factors also play a role on the level of NPLs. The econometric analysis shows that key bank-specific determinants are the CAR, ROAE and loans to assets ratio which indicate bank's solvency, performance and balance sheet diversification.

When evaluating the effect of the introduction of national AMC in the determinants of the NPL ratio, the estimations show that the level of the NPL ratio is lower and less persistent. For countries with national AMC,

the study suggests that in general the influence of bank-specific factors is lower. The macroeconomic factors remain the key determinants with the unemployment and the lending rate being the leading indicators. However, there are mixed results on the size and direction of the impact.

The findings of this study indicate that regulators should emphasize the role that management plays on the level of NPLs and the corporate responsibility on the overall wellness of the financial system. As such, regulators should allocate higher efforts on reviewing bank's policies and governance as well as credit risk monitoring systems in order to minimize the sources of risk. Furthermore, the analysis suggest that the introduction of national AMC facilitates the reduction of legacy NPLs improving bank's balance sheet and profitability and easing the attention of bank's management in core banking activities. Therefore, the study provides evidence in favor of the introduction of national AMCs as part of a comprehensive package for the reduction of the NPL stock of banks with very high levels of non-viable exposures.

The methodology can be applied for regulatory top-down stress testing as the linkage of the NPL ratio to macroeconomic indicators allows us to naturally provide forecast across alternative scenarios. The study can be extended adding segmentations to portfolio and loan types, as macroeconomic factors affect differently depending on the type of loans. Moreover, the model can be enriched by adding indicators of the target market or any indicator of customer's composition and characteristics to identify changes in the quality of loans through the credit cycle; which can be extended to develop early warning systems for credit risk.

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8. APPENDIX

8.1. Countries

Country Name	Total*		OECD Member		
	No. Banks	Percent	Member	Member since	Percent
ALBANIA	13	0.18			
ANGOLA	15	0.21			
ARGENTINA	44	0.6			
ARMENIA	14	0.19			
AUSTRALIA	64	0.87	Yes	Jun-1971	1.45
AUSTRIA	32	0.44	Yes	Sep-1961	0.73
AZERBAIJAN	26	0.36			
BAHRAIN	22	0.3			
BANGLADESH	18	0.25			
BELARUS	17	0.23			
BELGIUM	17	0.23	Yes	Sep-1961	0.39
BOLIVIA	12	0.16			
BOSNIA AND HERZEGOVINA	19	0.26			
BRAZIL	861	11.77			
BULGARIA	18	0.25			
CAMBODIA	23	0.31			
CANADA	101	1.38	Yes	Apr-1961	2.29
CHILE	19	0.26	Yes	May-2010	0.43
CHINA	151	2.06			
COLOMBIA	25	0.34			
COSTA RICA	44	0.6			
CROATIA	25	0.34			
CYPRUS	29	0.4			
CZECH REPUBLIC	22	0.3	Yes	Dec-1995	0.50
DENMARK	71	0.97	Yes	May-1961	1.61
DOMINICAN REPUBLIC	43	0.59			
ECUADOR	24	0.33			
EGYPT	23	0.31			
EL SALVADOR	13	0.18			
ESTONIA	8	0.11	Yes	Dec-2010	0.18
FINLAND	42	0.57	Yes	Jan-1969	0.95
FRANCE	196	2.68	Yes	Aug-1961	4.45
GEORGIA	16	0.22			
GERMANY	1,243	16.99	Yes	Sep-1961	28.24
GHANA	18	0.25			
GREECE	7	0.1	Yes	Sep-1961	0.16
GUATEMALA	14	0.19			
HAITI	8	0.11			

Country Name	Total*		OECD Member		
	No. Banks	Percent	Member	Member since	Percent
HONG KONG	25	0.34			
HUNGARY	12	0.16	Yes	May-1996	0.27
INDIA	31	0.42			
INDONESIA	102	1.39			
IRELAND	10	0.14	Yes	Aug-1961	0.23
ISRAEL	13	0.18	Yes	Sep-2010	0.30
ITALY	533	7.29	Yes	Mar-1962	12.11
JAMAICA	5	0.07			
JAPAN	545	7.45	Yes	Apr-1964	12.38
JORDAN	17	0.23			
KAZAKHSTAN	32	0.44			
KENYA	33	0.45			
KUWAIT	12	0.16			
LATVIA	13	0.18	Yes	Jul-2016	0.30
LEBANON	27	0.37			
LITHUANIA	6	0.08	Yes	Jul-2018	0.14
LUXEMBOURG	16	0.22	Yes	Dec-1961	0.36
MACEDONIA (FYROM)	8	0.11			
MALAYSIA	41	0.56			
MALTA	6	0.08			
MAURITIUS	13	0.18			
MEXICO	51	0.7	Yes	May-1994	1.16
MONTENEGRO	9	0.12			
MOROCCO	7	0.1			
MOZAMBIQUE	10	0.14			
NAMIBIA	5	0.07			
NEPAL	14	0.19			
NETHERLANDS	21	0.29	Yes	Nov-1961	0.48
NEW ZEALAND	16	0.22	Yes	May-1973	0.36
NICARAGUA	7	0.1			
NIGERIA	20	0.27			
NORWAY	123	1.68	Yes	Jul-1961	2.79
OMAN	10	0.14			
PANAMA	38	0.52			
PARAGUAY	13	0.18			
PERU	43	0.59			
PHILIPPINES	24	0.33			
POLAND	28	0.38	Yes	Nov-1996	0.64
PORTUGAL	106	1.45	Yes	Aug-1961	2.41
QATAR	11	0.15			
REPUBLIC OF KOREA	13	0.18	Yes	Dec-1996	0.30

Country Name	Total*		OECD Member		
	No. Banks	Percent	Member	Member since	Percent
REPUBLIC OF MOLDOVA	12	0.16			
ROMANIA	19	0.26			
RUSSIAN FEDERATION	425	5.81			
SAUDI ARABIA	14	0.19			
SENEGAL	6	0.08			
SERBIA	23	0.31			
SINGAPORE	7	0.1			
SLOVAKIA	12	0.16	Yes	Dec-2000	0.27
SLOVENIA	13	0.18	Yes	Jul-2010	0.30
SOUTH AFRICA	14	0.19			
SPAIN	73	1	Yes	Aug-1961	1.66
SRI LANKA	12	0.16			
SWEDEN	81	1.11	Yes	Sep-1961	1.84
SWITZERLAND	244	3.34	Yes	Sep-1961	5.54
TAIWAN	34	0.46			
THAILAND	21	0.29			
TRINIDAD AND TOBAGO	6	0.08			
TUNISIA	12	0.16			
TURKEY	47	0.64	Yes	Aug-1961	1.07
UGANDA	17	0.23			
UKRAINE	80	1.09			
UNITED ARAB EMIRATES	29	0.4			
UNITED KINGDOM	102	1.39	Yes	May-1961	2.32
UNITED REPUBLIC OF TANZANIA	24	0.33			
UNITED STATES OF AMERICA	501	6.85	Yes	Apr-1961	11.38
URUGUAY	10	0.14			
UZBEKISTAN	4	0.05			
VIETNAM	24	0.33			
ZAMBIA	13	0.18			
ZIMBABWE	10	0.14			
Total	7,315	100	4,401		100

*Total excludes countries with non-available macroeconomic data.

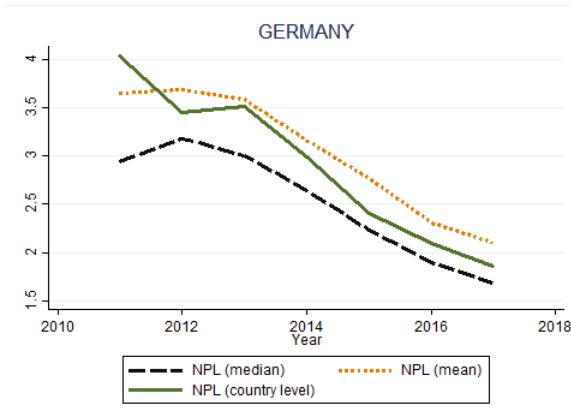
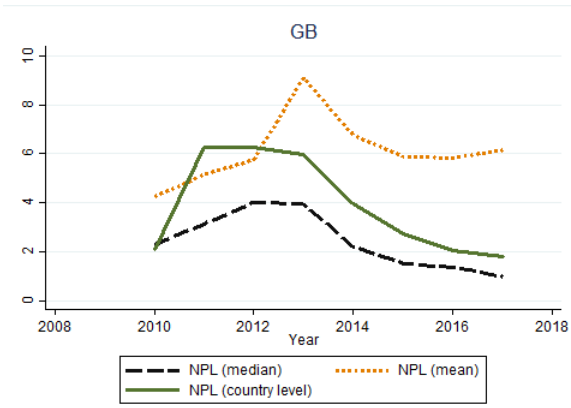
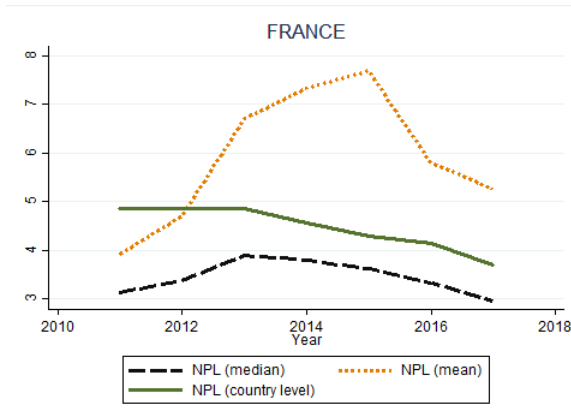
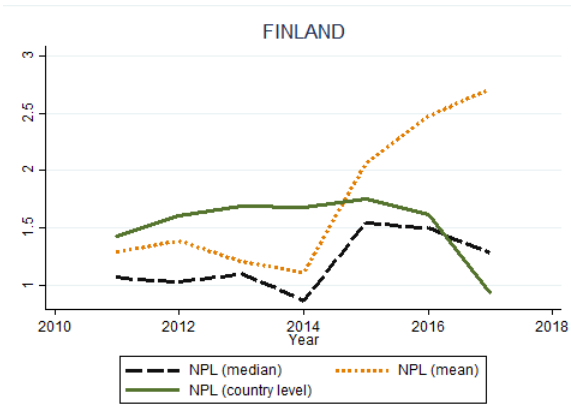
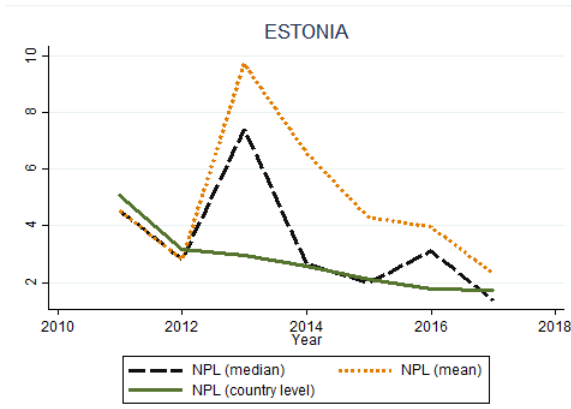
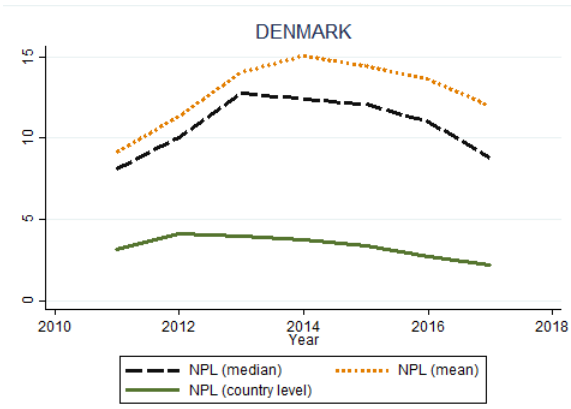
8.2. Summary statistics

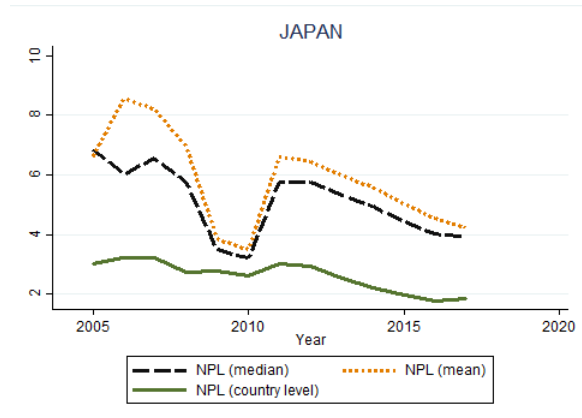
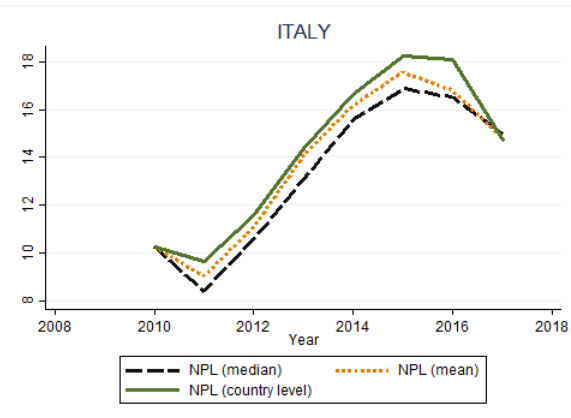
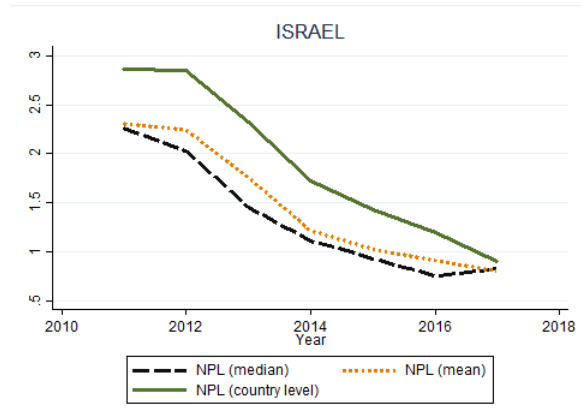
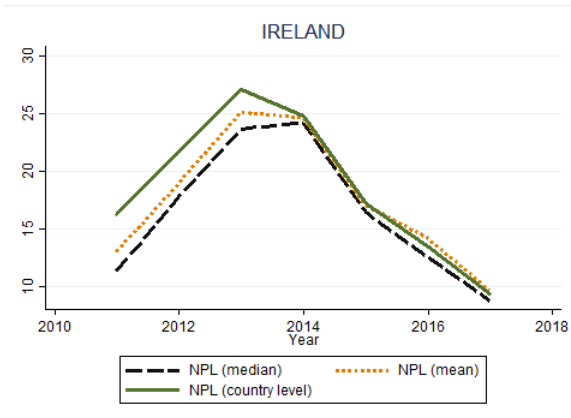
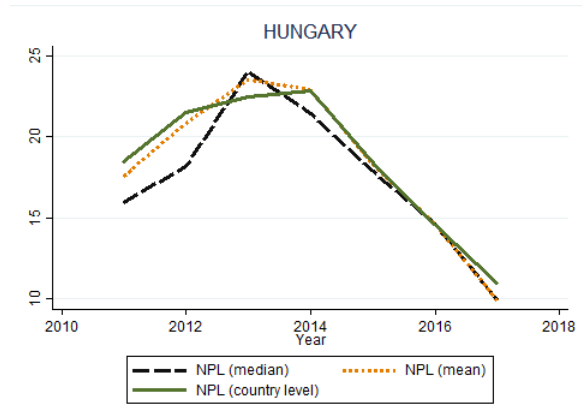
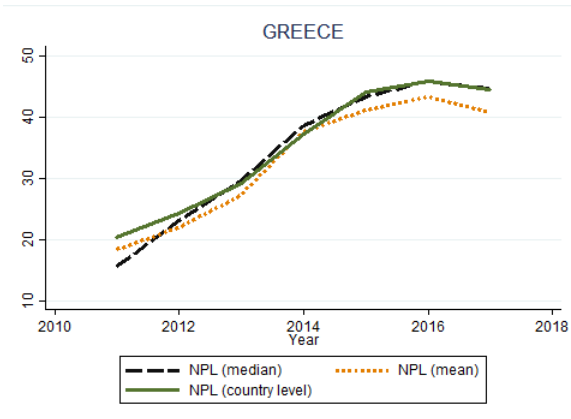
Variable	N	Mean	Min	P1	P5	P10	P25	Median	P75	P90	P95	P99	Max
NPL ratio	24,821	5.47	0.00	0.00	0.11	0.32	1.00	2.79	6.62	14.08	20.11	34.27	100.00
CAR	19,146	17.97	0.36	8.42	11.18	12.15	13.89	16.43	19.87	24.78	29.82	48.28	98.96
ROAE	24,868	4.26	-148.95	-35.41	-4.94	0.62	1.95	3.86	7.23	11.89	15.64	27.39	121.33
ROAA	25,073	0.39	-49.73	-3.19	-0.43	0.04	0.14	0.29	0.66	1.12	1.49	3.34	37.66
LLR to TL	24,772	2.88	-13.22	0.01	0.09	0.24	0.69	1.39	3.04	6.94	10.29	19.46	100.00
Non-II to OR	25,062	28.94	-863.30	-10.50	3.10	8.13	17.06	28.16	38.43	49.71	59.93	90.96	903.74
LtoA	25,074	60.77	0.00	8.14	27.11	36.61	49.55	62.76	74.20	83.47	87.43	93.00	99.87
LtoD	24,334	96.36	0.00	14.57	38.78	46.61	66.59	87.18	111.71	143.53	180.34	328.02	991.52
GDPYoY	29,219	1.48	-9.13	-2.82	-1.73	0.11	0.69	1.57	2.22	2.88	3.72	5.31	25.01
CPI	29,219	1.20	-1.64	-1.14	-0.43	-0.16	0.14	1.14	1.96	2.78	3.32	6.47	11.14
CPIYoY	24,818	69.85	-2800.00	-2752.00	-611.56	146.30	-81.20	-39.54	68.16	334.18	704.66	8653.85	25318.18
LendingRate	28,839	2.76	0.88	0.88	1.08	1.21	1.58	2.69	3.50	4.80	5.22	6.97	10.06
U	29,219	6.72	2.84	2.88	3.12	3.38	4.32	5.27	8.52	11.66	12.13	22.06	27.48
StockYoY	23,071	7.71	-51.88	-22.46	-16.36	-9.01	0.40	8.63	16.86	21.37	24.21	48.74	55.80

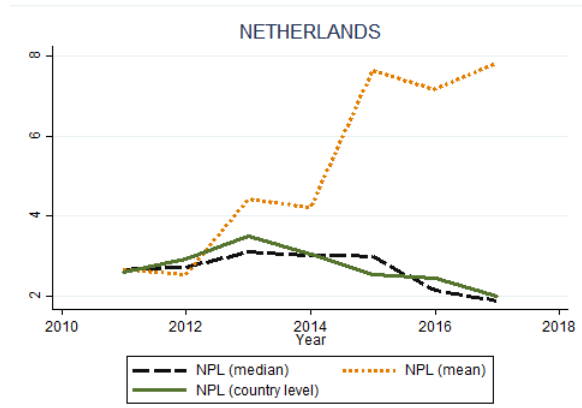
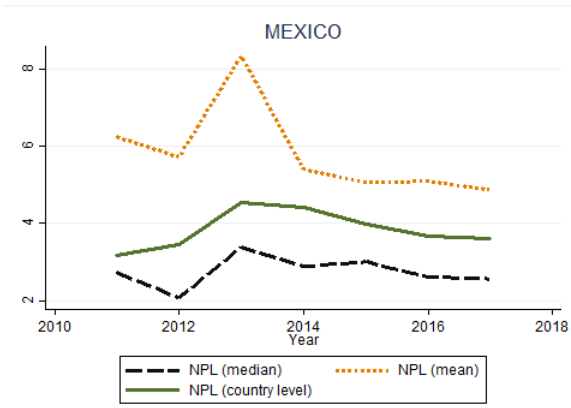
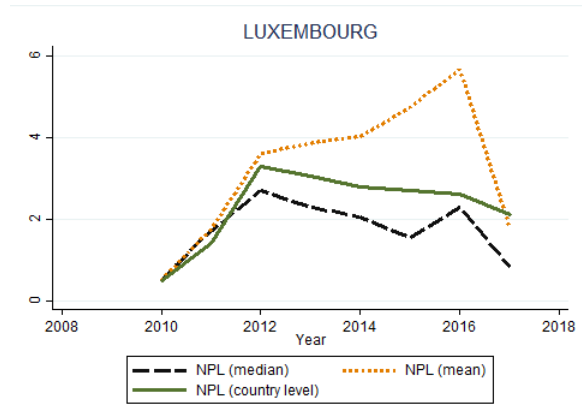
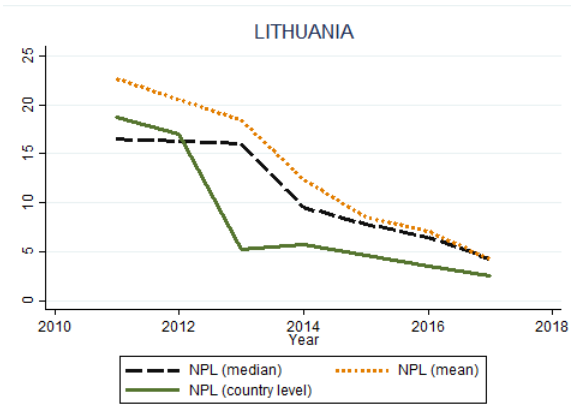
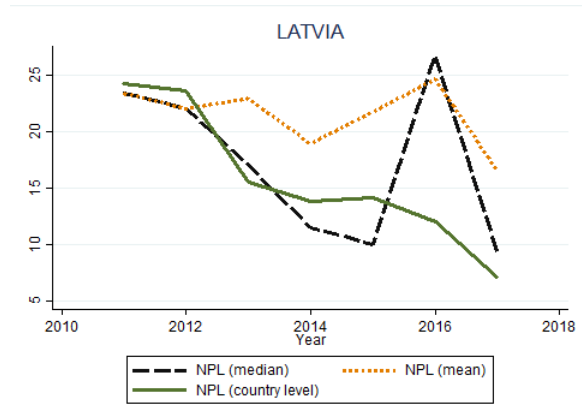
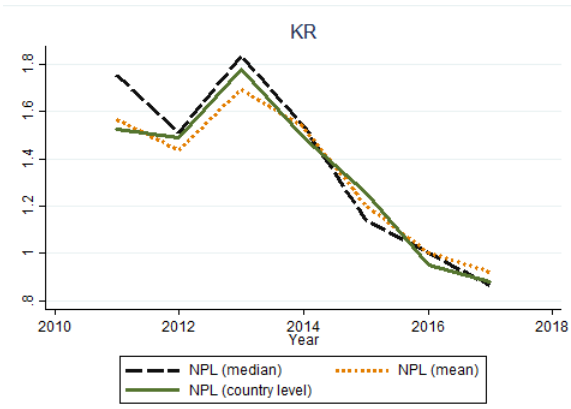
Summary statistics of bank-specific and macroeconomic variables for banks from OCDE countries. Bank-specific data is sourced from Moody's Analytics BankFocus and macroeconomic data from IMF retrieved from Moody's Analytics DataBuffet.

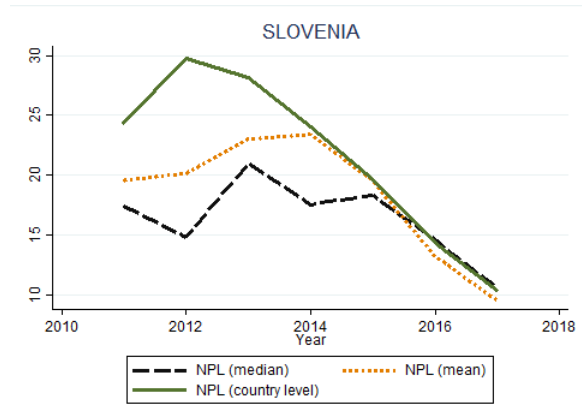
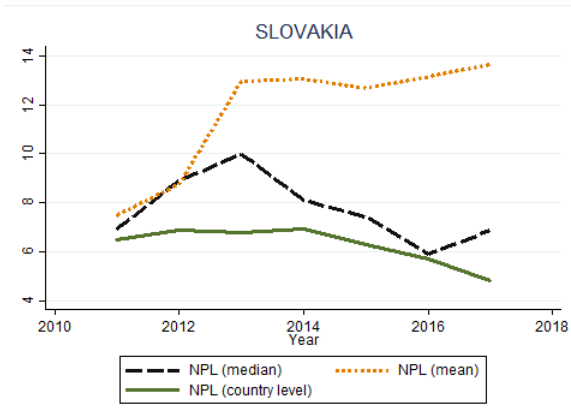
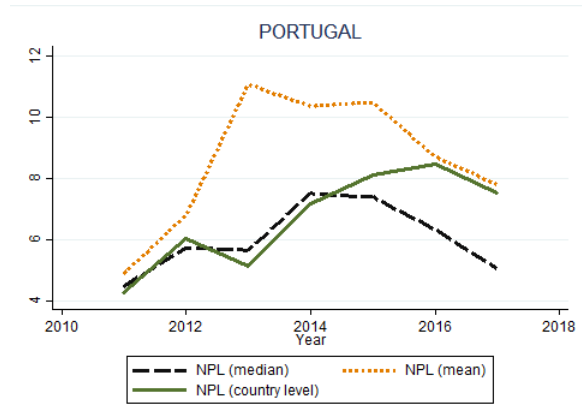
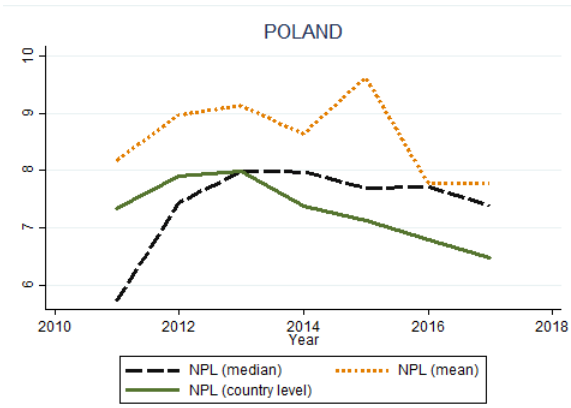
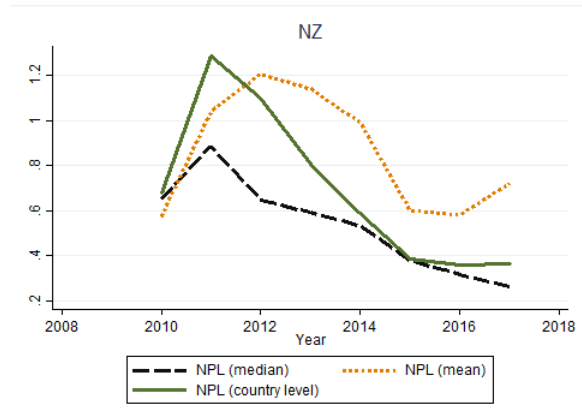
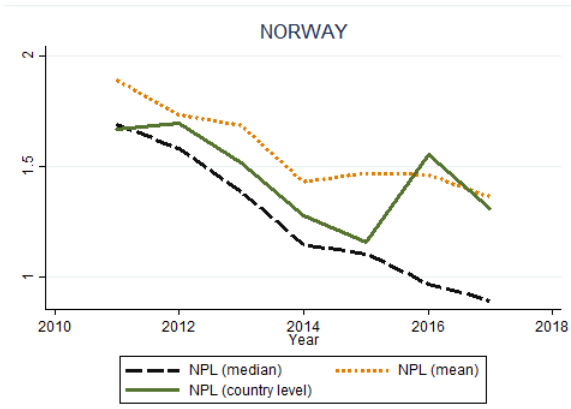
8.3. NPL ratios across time

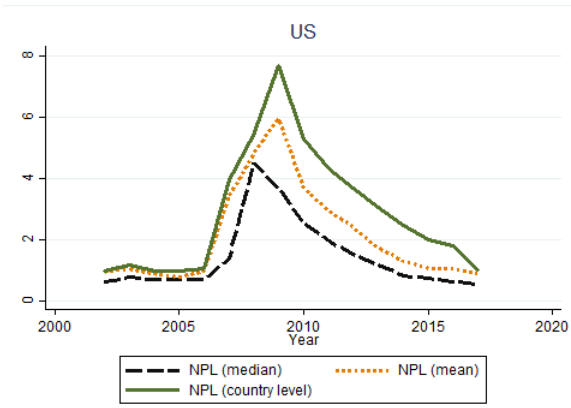
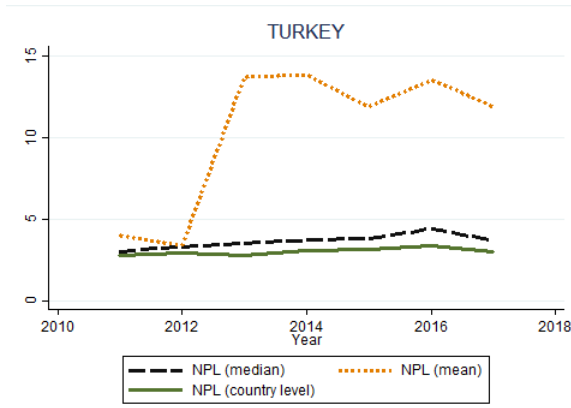
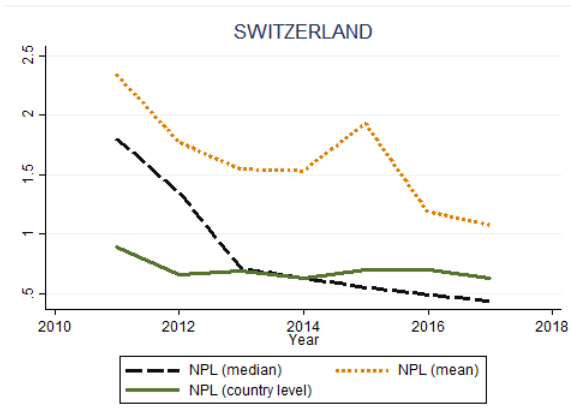
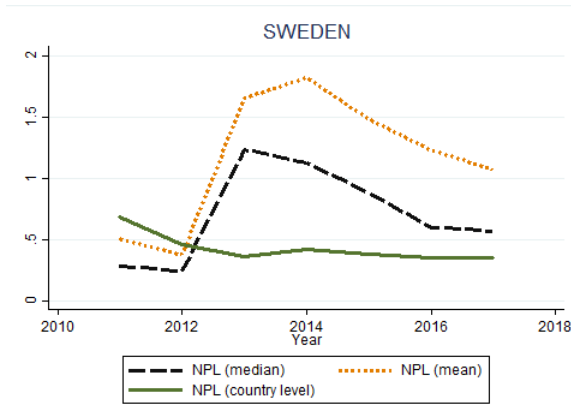
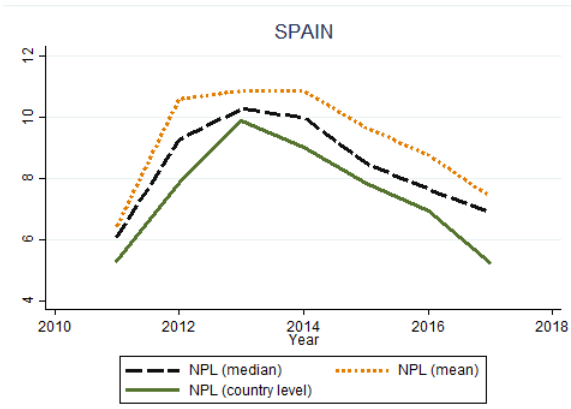












8.4. Correlation matrix

	NPL ratio	CAR	ROAE	ROAA	LLR to TL	Non-II to OR	LtoA	LtoD	GDP YoY	Inflation	Lending Rate	U	Stock YoY
NPL ratio	1.00	0.02	-0.37	-0.32	0.87	0.19	-0.19	0.15	-0.32	-0.14	0.29	0.56	0.00
CAR	0.02	1.00	0.01	0.05	0.05	0.07	-0.32	-0.09	0.00	-0.10	-0.09	0.05	-0.03
ROAE	-0.37	0.01	1.00	0.85	-0.31	-0.05	0.06	-0.04	0.19	0.16	0.04	-0.15	0.13
ROAA	-0.32	0.05	0.85	1.00	-0.26	-0.03	0.09	-0.01	0.20	0.18	0.06	-0.14	0.14
LLR to TL	0.87	0.05	-0.31	-0.26	1.00	0.17	-0.23	0.12	-0.20	-0.10	0.26	0.50	0.01
Non-II to OR	0.19	0.07	-0.05	-0.03	0.17	1.00	-0.28	0.01	-0.09	-0.14	-0.04	0.17	-0.01
LtoA	-0.19	-0.32	0.06	0.09	-0.23	-0.28	1.00	0.41	0.07	0.13	0.10	-0.15	0.02
LtoD	0.15	-0.09	-0.04	-0.01	0.12	0.01	0.41	1.00	-0.18	0.10	0.22	0.17	-0.03
GDP YoY	-0.32	0.00	0.19	0.20	-0.20	-0.09	0.07	-0.18	1.00	-0.16	-0.33	-0.40	0.18
Inflation	-0.14	-0.10	0.16	0.18	-0.10	-0.14	0.13	0.10	-0.16	1.00	0.47	-0.04	0.07
LendingRate	0.29	-0.09	0.04	0.06	0.26	-0.04	0.10	0.22	-0.33	0.47	1.00	0.39	0.07
U	0.56	0.05	-0.15	-0.14	0.50	0.17	-0.15	0.17	-0.40	-0.04	0.39	1.00	-0.03
StockYoY	0.00	-0.03	0.13	0.14	0.01	-0.01	0.02	-0.03	0.18	0.07	0.07	-0.03	1.00

8.5. Summary of model specifications

Type	Variable	Models					
		1	2	3	4	5	6
Bank-specific	CAR	✓	✓	✓	✓	✓	✓
	ROAE	✓	✓	✓	✓	✓	✓
	LLR to TL	✓	✓	✓	✓	✓	✓
	Non-II to OR	✓	✓	✓	✓	✓	✓
	LtoA	✓	✓	✓			
	LtoD				✓	✓	✓
Macroeconomic	GDPYoY	✓	✓		✓	✓	
	StockYoY	✓		✓	✓		✓
	U	✓	✓	✓	✓	✓	✓
	CPI	✓	✓	✓	✓	✓	✓
	Lending Rate	✓	✓	✓	✓	✓	✓

8.6. Estimation results for the benchmark analysis

Dependent variable: NPL ratio

	Models					
	1	2	3	4	5	6
L1.NPL ratio	0.61179 *** (0)	0.51927 *** (0)	0.59622 *** (0)	0.58620 *** (0)	0.48580 *** (0)	0.59583 *** (0)
CAR	-0.00544 (0.648)	-0.01033 (0.278)	-0.03267 (0.007)	0.00873 (0.157)	0.00324 (0.663)	0.01484 (0.009)
L1	-0.05082 *** (0)	-0.05306 *** (0)	-0.03677 *** (0)	-0.05463 *** (0)	-0.05698 *** (0)	-0.07047 *** (0)
ROAE	-0.06947 (0)	-0.07433 (0)	-0.06837 (0)	-0.06693 (0)	-0.07140 (0)	-0.06364 (0)
L1	-0.00458 *** (0.01)	-0.00933 *** (0)	-0.00778 *** (0)	-0.01115 *** (0)	-0.01470 *** (0)	-0.01160 *** (0)
Non-II to OR	-0.00448 (0.101)	0.00138 (0.679)	-0.00335 (0.207)	-0.00050 (0.877)	0.00659 (0.652)	0.00153 (0.594)
L1	0.00528 *** (0)	0.00326 *** (0)	0.00338 *** (0)	0.00540 *** (0)	0.00384 *** (0)	0.00586 *** (0)
LtoA	-0.04412 (0)	-0.06071 (0)	-0.04938 (0)			
L1	0.01488 *** (0.001)	0.01584 *** (0)	0.01906 *** (0)			
LtoD				-0.00747 (0)	-0.00794 (0)	-0.00603 (0)
L1				-0.00050 (0.401)	-0.00304 (0)	-0.00213 (0.002)
Inflation	-0.03831 (0.188)	-0.06590 (0.02)	-0.05486 (0.037)	-0.05433 (0.064)	-0.07612 (0.005)	-0.07068 (0.006)
L1	0.07279 *** (0.01)	0.07916 *** (0.001)	0.09249 *** (0)	0.04371 (0.134)	0.05710 (0.028)	0.10085 (0)
GDPYoY	-0.07353 (0.019)	-0.01023 (0.703)		-0.09103 (0.003)	-0.03639 (0.147)	
L1	-0.07054 *** (0.004)	-0.00237 (0.911)		-0.08041 (0.002)	-0.02615 (0.234)	
U	-0.09664 (0.148)	0.01809 (0.766)	0.02238 (0.705)	-0.03766 (0.606)	0.01317 (0.83)	0.06819 (0.255)
L1	0.25486 *** (0)	0.16009 *** (0.003)	0.18215 *** (0.001)	0.20235 *** (0.002)	0.18287 *** (0.001)	0.11293 (0.043)
StockYoY	0.00172 (0.494)		0.00267 (0.257)	0.00458 (0.056)		0.00484 (0.027)
L1	0.00212 (0.344)		0.00204 (0.346)	0.00218 (0.344)		0.00241 (0.263)
LendingRate	0.04496 (0.589)	-0.12181 (0.127)	0.12144 (0.151)	-0.03452 (0.65)	-0.22577 (0.001)	0.04934 (0.508)
L1	0.54428 *** (0)	0.57955 *** (0)	0.49544 *** (0)	0.64023 *** (0)	0.78362 *** (0)	0.62029 *** (0)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Legend: * p<.1; ** p<.05; *** p<.01						
Number of obs	10,280	11,724	10,280	10,078	11,500	10,078
Number of groups	3,340	3,409	3,340	3,282	3,347	3,282
Number of instruments	330	328	328	326	324	324
Arellano-Bond AR(1) p-value	0.000	0.002	0.000	0.000	0.003	0.000
Arellano-Bond AR(2) p-value	0.755	0.918	0.743	0.861	0.968	0.825
Hansen test, p-value	0.572	0.216	0.594	0.133	0.100	0.629
F	32650.767	6502.578	71789.751	18112.752	195235.945	5477.475
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000

Two-step difference GMM with small-sample corrections to the covariance matrix estimate and orthogonal deviations. The lag of the NPL ratio and bank-specific variables are endogenous. The appropriate range for the first lag of the NPL ratio, obtained from the fixed effects and pooled OLS estimators, is from 0.29 to 0.88 for Models 1 to 3. The boundaries for Models 4 to 6 is from 0.29 to 0.87.

Dependent variable: NPL ratio

	Models					
	1	2	3	4	5	6
L1.NPL ratio	0.61937 *** (0)	0.52164 *** (0)	0.59622 *** (0)	0.61981 *** (0)	0.51034 *** (0)	0.59583 *** (0)
CAR	0.00082 (0.931)	-0.01550 (0.162)	-0.03267 (0.007)	0.02890 (0)	0.00512 (0.584)	0.01484 (0.009)
L1	-0.05247 *** (0)	-0.05587 *** (0)	-0.03677 *** (0)	-0.07932 *** (0)	-0.05827 *** (0)	-0.07047 *** (0)
ROAE	-0.07281 *** (0)	-0.07275 *** (0)	-0.06837 *** (0)	-0.07330 *** (0)	-0.06832 *** (0)	-0.06364 *** (0)
L1	-0.00557 *** (0.001)	-0.01141 *** (0)	-0.00778 *** (0)	-0.00969 *** (0)	-0.01786 *** (0)	-0.01160 *** (0)
Non-II to OR	-0.00381 (0.161)	0.00297 (0.338)	-0.00335 (0.207)	0.00399 (0.223)	0.00842 (0.007)	0.00153 (0.594)
L1	0.00510 *** (0)	0.00468 *** (0)	0.00338 *** (0)	0.00594 *** (0)	0.00663 *** (0)	0.00586 *** (0)
LtoA	-0.04770 *** (0)	-0.06889 *** (0)	-0.04938 *** (0)			
L1	0.01755 *** (0)	0.01854 *** (0)	0.01906 *** (0)			
LtoD				-0.00695 (0)	-0.00724 (0)	-0.00603 (0)
L1				-0.00075 (0.168)	-0.00135 (0.025)	-0.00213 (0.002)
Inflation	-0.06216 *** (0.007)	-0.07532 *** (0.001)	-0.05486 *** (0.037)	-0.05294 *** (0.019)	-0.07124 *** (0)	-0.07068 *** (0.006)
L1	0.07897 *** (0.001)	0.07769 *** (0)	0.09249 *** (0)	0.05442 *** (0.031)	0.05978 *** (0.007)	0.10085 *** (0)
GDPYoY	-0.05244 * (0.084)	-0.01145 (0.679)		-0.06829 (0.034)	-0.01364 (0.627)	
L1	-0.05252 *** (0.01)	0.01147 (0.501)		-0.08082 (0)	-0.01139 (0.48)	
U	-0.04887 (0.437)	0.01296 (0.813)	0.02238 (0.705)	-0.08864 (0.154)	0.04138 (0.481)	0.06819 (0.255)
L1	0.19112 *** (0.001)	0.16363 *** (0.001)	0.18215 *** (0.001)	0.19261 *** (0.001)	0.13977 *** (0.006)	0.11293 ** (0.043)
StockYoY	0.00410 ** (0.026)		0.00267 (0.257)	0.00623 (0.002)		0.00484 (0.027)
L1	0.00034 (0.851)		0.00204 (0.346)	0.00018 (0.92)		0.00241 (0.263)
LendingRate	0.09367 (0.175)	-0.02888 (0.678)	0.12144 (0.151)	0.01250 (0.842)	-0.11321 (0.079)	0.04934 (0.508)
L1	0.39281 *** (0)	0.43035 *** (0)	0.49544 *** (0)	0.52549 *** (0)	0.57279 *** (0)	0.62029 *** (0)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes

Legend: * p<.1; ** p<.05; *** p<.01

Number of obs	10,280	11,724	10,280	10,078	11,500	10,078
Number of groups	3,340	3,409	3,340	3,282	3,347	3,282
Number of instruments	388	386	328	383	381	324
Arellano-Bond AR(1) p-value	0.000	0.002	0.000	0.000	0.003	0.000
Arellano-Bond AR(2) p-value	0.725	0.901	0.743	0.803	0.987	0.825
Hansen test, p-value	0.201	0.124	0.594	0.069	0.039	0.629
F	6751.063	9422.192	71789.751	22689.051	59677.320	5477.475
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000

Two-step difference GMM with small-sample corrections to the covariance matrix estimate and orthogonal deviations. The lag of the NPL ratio, bank-specific variables and the annual growth of GDP are endogenous. The appropriate range for the first lag of the NPL ratio, obtained from the fixed effects and pooled OLS estimators, is from 0.29 to 0.88 for Models 1 to 3. The boundaries for Models 4 to 6 is from 0.29 to 0.87.

8.7. List of countries with national AMCs in Europe

Year of the introduction	Country	AMC
2015	Hungary	MARK
2014	Austria	HETA
2013	Slovenia	DUTB/BAMC
2012	Spain	SAREB
2010	Germany	FMS
2010	UK	UK Asset Resolution
2009	Ireland	NAMA
2009	Germany	EAA
1996	Italy	SGA

8.8. Estimation results for models measuring the impact of AMCs

Dependent variable: NPL ratio

	Models									
	3		6		3		6		4	
L1.NPL ratio	0.70254	***	0.67364	***	0.73499	***	0.71201	***	0.66636	***
	(0)		(0)		(0)		(0)		(0)	
AMCxL1.NPL ratio	-0.02994		-0.04054	*	-0.04835	**	-0.05611	**	-0.02893	
	(0.19917)		(0.07388)		(0.04146)		(0.01224)		(0.16007)	
AMC	-7.51877	***	-5.21171	***	-6.35552	***	-3.25432	***	-3.00781	***
	(0)		(0)		(0.00002)		(0.00094)		(0.00122)	
CAR	-0.00309		-0.01271		-0.03177		-0.00913		-0.00946	
	(0.91158)		(0.61143)		(0.25719)		(0.71616)		(0.66102)	
L1.CAR	-0.07471	***	-0.08229	***	-0.06333	***	-0.08007	***	-0.05523	***
	(0.00015)		(0.00007)		(0.00123)		(0.00006)		(0.00244)	
AMCxCAR	0.04345	*	0.01692		0.05108	**	0.00758		0.00256	
	(0.08053)		(0.39268)		(0.04883)		(0.71922)		(0.88871)	
L1.AMCxCAR	0.06841	***	0.06856	***	0.05890	***	0.05912	***	0.06786	***
	(0.00004)		(0.00004)		(0.00046)		(0.00056)		(0.00002)	
ROAE	-0.08981	***	-0.07891	***	-0.06683	***	-0.06209	***	-0.09663	***
	(0)		(0)		(0)		(0)		(0)	
L1.ROAE	-0.02382	***	-0.02442	***	-0.01711	***	-0.02244	***	-0.01300	***
	(0.0001)		(0.00003)		(0.00464)		(0.00044)		(0.00892)	
AMCxROE	0.04264	***	0.02190		0.03231	**	0.01468		0.03777	***
	(0.0031)		(0.13961)		(0.02408)		(0.31281)		(0.00844)	
L1.AMCxROE	-0.02890	***	-0.03759	***	-0.03057	***	-0.03791	***	-0.02658	***
	(0.0024)		(0.00004)		(0.00146)		(0.0001)		(0.00246)	
Non-II to OR	-0.01826	**	-0.00297		-0.02150	***	-0.00703		0.00458	
	(0.01969)		(0.64474)		(0.00293)		(0.25473)		(0.48795)	
L1.Non-II to OR	0.01240	**	0.01683	***	0.01018	*	0.01406	***	0.01460	***
	(0.02053)		(0)		(0.0571)		(0.00011)		(0)	
AMCxNon-II to OR	0.02161	**	0.01228	*	0.02339	***	0.01453	**	0.00396	
	(0.01282)		(0.07005)		(0.00351)		(0.02336)		(0.563)	
L1.AMCxNon-II to OR	-0.00693		-0.00680	*	-0.00674		-0.00493		-0.00616	*
	(0.20562)		(0.08725)		(0.22222)		(0.23673)		(0.0834)	
LtoA	-0.04026	*			-0.02629					
	(0.05232)				(0.21015)					
L1.LtoA	-0.01536				-0.01878					
	(0.31147)				(0.21092)					
AMCxLtoA	0.04832	***			0.05251	***				
	(0.00117)				(0.0004)					
L1.AMCxLtoA	-0.00404				-0.00947					
	(0.63847)				(0.25623)					
LtoD			-0.00415	*			-0.00274		-0.00128	
			(0.07521)				(0.19968)		(0.55452)	
L1.LtoD			-0.00205				0.00031		-0.00314	
			(0.41208)				(0.8926)		(0.17529)	
AMCxLtoD			0.00863	***			0.00651	***	0.00566	**
			(0.00084)				(0.00941)		(0.01881)	
L1.AMCxLtoD			-0.00204				-0.00343		-0.00163	
			(0.39802)				(0.13578)		(0.47006)	
Inflation	0.06193	**	0.06298	**	0.08059	***	0.07193	***	0.03579	
	(0.0223)		(0.02264)		(0.0018)		(0.00777)		(0.11364)	
L1.Inflation	-0.21856	***	-0.25487	***	-0.04746		-0.04323		-0.26318	***
	(0)		(0)		(0.20926)		(0.27165)		(0)	
AMCxInflation	0.00010		-0.00001		0.00013	**	0.00009		-0.00010	

	Models									
	3		6		3		6		4	
	(0.1299)		(0.89509)		(0.04936)		(0.15339)		(0.16321)	
L1.AMCxInflation	0.00104 ***		0.00114 ***		0.00077 ***		0.00093 ***		0.00161 ***	
	(0)		(0)		(0.0005)		(0.00006)		(0)	
GDPYoY									-0.11645 *	
									(0.06073)	
L1.GDPYoY									0.01093	
									(0.72726)	
AMCxGDPYoY									-0.04193	
									(0.51406)	
L1.AMCxGDPYoY									-0.17975 ***	
									(0.00001)	
U	0.16669 ***		0.18518 ***		0.21401 ***		0.14188 *		0.07221	
	(0.00648)		(0.00277)		(0.00187)		(0.06426)		(0.25365)	
L1.U	0.10176 *		0.08439		0.06571		0.11723 *		0.15199 ***	
	(0.06643)		(0.12555)		(0.27793)		(0.06767)		(0.004)	
AMCxU	0.15362 ***		0.19216 ***		0.09365		0.15764 ***		0.11868 **	
	(0.00505)		(0.00046)		(0.12694)		(0.00732)		(0.02571)	
L1.AMCxU	-0.11789 ***		-0.12813 ***		-0.09315 **		-0.11647 ***		-0.11999 ***	
	(0.00542)		(0.0024)		(0.03606)		(0.00944)		(0.00445)	
StockYoY	0.01291 ***		0.01613 ***		0.01391 ***		0.01376 ***		0.01752 ***	
	(0.00001)		(0)		(0)		(0)		(0)	
L1.StockYoY	-0.01174 ***		-0.01023 ***		-0.00605 **		-0.00403		-0.00940 ***	
	(0.00005)		(0.00151)		(0.03304)		(0.16577)		(0.00302)	
AMCxStockYoY	-0.01280 ***		-0.02400 ***		-0.02319 ***		-0.02832 ***		-0.03363 ***	
	(0.00674)		(0)		(0.00001)		(0)		(0)	
L1.AMCxStockYoY	0.01325 ***		0.00833		0.00619		0.00030		0.00110	
	(0.00333)		(0.10687)		(0.1742)		(0.94916)		(0.81483)	
LendingRate	0.20971 **		0.18597 **		-0.14278		-0.11072		0.08175	
	(0.03248)		(0.03677)		(0.22836)		(0.35023)		(0.35074)	
L1.LendingRate	-0.01229		0.04041		0.09053		0.11062		0.19923 **	
	(0.90212)		(0.66607)		(0.44001)		(0.35515)		(0.02298)	
AMCxLendingRate	0.23906		0.26865		0.00106		-0.06859		0.07021	
	(0.14155)		(0.10417)		(0.99397)		(0.6377)		(0.66987)	
L1.AMCxLendingRate	0.11077		0.14939		0.18775		0.23839 *		0.18885 *	
	(0.3894)		(0.26292)		(0.17167)		(0.08345)		(0.09435)	
Endogenous macroeconomic variable	Inflation		Inflation		Lending Rate		Lending Rate		Inflation and GDPYoY	

legend: * p<.1; ** p<.05; *** p<.01

Number of obs	6,595	6,466	6,595	6,466	6,466
Number of groups	2,542	2,502	2,542	2,502	2,502
Number of instruments	231	231	231	231	262
Arellano-Bond AR(1) p-value	0.000	0.000	0.000	0.000	0.000
Arellano-Bond AR(2) p-value	0.923	0.712	0.934	0.757	0.600
Hansen test, p-value	0.210	0.244	0.146	0.112	0.141
F	206.833	206.160	178.998	206.198	4780.164
Prob > F	0.000	0.000	0.000	0.000	0.000

Two-step difference GMM with small-sample corrections to the covariance matrix estimate and orthogonal deviations. The lag of the NPL ratio, bank-specific variables and selected macroeconomic factors are endogenous. The appropriate range for the first lag of the NPL ratio, obtained from the fixed effects and pooled OLS estimators, is from 0.13 to 0.78 for Models 1 to 3. The boundaries for Models 4 to 6 is from 0.12 to 0.78.

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