GreeSE Papers

Hellenic Observatory Discussion Papers
on Greece and Southeast Europe

Paper No. 160

Determinants of Non-Performing Loans in Greece: the intricate role of fiscal expansion

Maria Karadima and Helen Louri

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

June 2021

HELLENIC OBSERVATORY
European Institute
Research at LSE

Determinants of Non-Performing Loans in Greece: the intricate role of fiscal expansion

Maria Karadima and Helen Louri

GreeSE Paper No. 160

Hellenic Observatory Papers on Greece and Southeast Europe

Contents

Determinants of Non-Performing Loans in Greece: the intricate role of fiscal expansion

Maria Karadima* **and Helen Louri†**

ABSTRACT

Following the financial and debt crises in the euro area and the delays in formulating a cohesive policy response, Greek banks faced serious problems with the increase in non-performing loans (NPLs) being the most threatening. In this study, we attempt to empirically investigate the determinants of NPLs in the Greek banking sector, using quarterly aggregate data for the period 2003Q1-2020Q2 and the autoregressive distributed lag (ARDL) bounds testing approach. We find that NPLs are determined mostly by factors related to macroeconomic conditions in Greece during the period under investigation, rather than by bank-related factors. Of particular interest is the case of government debt, which is found to exert a significant and positive long-term impact on NPLs irrespective of some short-term dynamics that appear to provide a temporary relief. The fiscal balance is also found to exert a negative long-term effect, justifying the quest for surpluses post-crisis. As debt accumulation is a policy followed by most countries in order to stabilize economies hit by the COVID-19 crisis, its long-term effects on the financial system should be taken into account and institutional measures introduced to face the new risk.

Keywords: Greece, Non-performing loans, fiscal expansion, ARDL, Bounds testing

JEL Classification: C22, G21

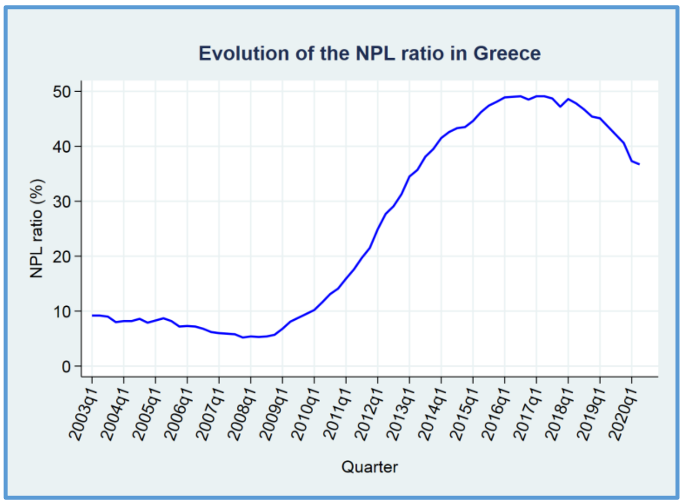
* Post-doctoral researcher, Athens University of Economics and Business, Department of Economics, e-mail: karadimam@aueb.gr

† Corresponding author: Professor, Athens University of Economics and Business, Department of Economics, Research Associate, London School of Economics, EI/HO, e-mail: elouri@aueb.gr

1. Introduction

The ratio of non-performing loans to total gross loans (NPL ratio) in Greece increased sharply during the global financial crisis of 2008 and the subsequent sovereign debt crisis. As is shown in Fig. 1, the NPL ratio in Greece started increasing in the first quarter of 2009 (2009Q1), reaching a peak of 49.1% in 2016Q3. It started falling afterwards, arriving at 35.38% in 2020Q3, which can be compared to the euro area average of 3% in the same period. In absolute terms NPLs reached 58.7 bn euro in 2020Q3 from their highest level of 107.2 bn in 2016Q1 and 68.5 bn at the end of 2019 (Bank of Greece, 2021).

Figure 1. Evolution of the NPL ratio in Greece. Source: Bank of Greece



The unprecedented high levels of NPLs in Greece place serious constraints on the lending capacity of banks (Louri and Migiakis, 2019), thereby significantly weakening investment and economic activity and placing the country at a disadvantage compared to other euro area members. As Hardouvelis (2021) notes in an extensive paper on the Greek banking sector, NPLs continue to be the critical problem of the Greek banking system and the Greek economy. Therefore, profound analysis and understanding of their determinants are essential in order to introduce measures leading to their effective control.

In 2020 the COVID-19 pandemic drove the Greek economy into a deep recession and deflation and led to increases in fiscal deficit, uncertainty and credit risk. New NPLs have been added on the legacy assets already existing on banks' balance sheets. It is expected that the COVID-related NPLs will reach 8-10 bn euro in 2021 (Bank of Greece, 2021). Due to the large contraction of GDP reaching 8.2% in 2020 vs. a contraction of 6.8% in the euro area fiscal support measures of more than 9% of GDP have been undertaken to support businesses and employment. Fiscal measures of 6.5% of GDP are planned to be adopted in 2021 (Bank of Greece, 2020). Such measures, although necessary for stabilizing the badly hit economy, will increase government debt and its servicing needs in the future potentially leading to tax increases or other second-round effects, which will be of a contractionary nature. How will NPLs be affected by expansionary measures in the short-run and in the long-run? This is the question we want to focus on in our study. If the long-run effect is positive, then drastic institutional measures, such as the creation of an asset management company or the introduction of new government guaranteed securitization schemes could be the major (if not the only) weapon to face the risk.

As presented in detail in Section 2 of this study, the investigation of the determinants of NPLs in the Greek banking sector has been conducted by using different econometric methods and datasets over different time periods. The present study investigates the determinants of NPLs in Greece using quarterly aggregate data for the period 2003Q1-2020Q2 and the autoregressive distributed lag (ARDL) bounds testing approach. This approach proposed by Pesaran et al. (2001) facilitates the examination of a long-run relationship between variables that are purely I(0), purely I(1), or a mixture of both. To the best of our knowledge, this is the first attempt to use the above econometric method in order to investigate the determinants of NPLs in Greece and distinguish their short- and long-term effects. Furthermore, it is the first time that an empirical research on the Greek NPLs extends up to the 2020Q2, thus covering the early phase of the COVID-19 pandemic in Greece.

The rest of the study is organized as follows. Section 2 reviews the literature on NPLs and more generally on credit risk in Greece. Section 3 describes the data and the econometric model, while Section 4 presents the econometric methodology. Section 5 presents the empirical results and Section 6 concludes.

2. Literature review

After the global financial crisis and as NPLs had become the most serious problem of many banks and banking systems, numerous studies were published attempting to understand the determinants and the dynamics of the phenomenon. The general empirical approach is that NPLs are determined by two groups of factors: country-related and bank-related. In particular, macroeconomic conditions, such as GDP growth (Anastasiou et al., 2016; Jimenez and Saurina, 2006), unemployment (Louzis et al., 2012; Rinaldi and Sanchis-Arellano, 2006), interest rates (Espinoza and Prasad, 2010; Louzis et al., 2012), inflation/deflation (Ghosh, 2015; Nkusu, 2011; Vithessonthi, 2016), exchange rates (Beck et al., 2015; Klein, 2013) as well as external deficits being a sign of competitiveness loss (Kauko, 2012) have been found to be major determinants of NPLs. Factors related to the functioning of the banking sector, such as the degree of competition and the level of concentration have also been estimated in cross-country studies to affect risk taking and NPLs (Anginer et al, 2014; Kick and Prieto, 2015; Karadima and Louri, 2020). Other bank-related characteristics representing the quality of management, such as cost efficiency (Podpiera and Weill, 2008; Koju et al., 2018), bank performance (Anastasiou et al., 2019b; Louzis et al., 2012; Makri et al., 2014) and bank capitalization (Ghosh, 2015; Koju et al., 2018) have also been documented to influence NPLs. In this section we present in a more detailed way only studies referring to NPLs in Greece as most of them have not been presented in a comprehensive, country-specific framework until now.

There are empirical studies that proceed to a breakdown of total loans into the main three categories: consumer, mortgage, and business loans. Louzis et al. (2012) examine the macro and bank-specific determinants of NPLs in the Greek banking sector, separately for consumer loans, mortgage loans, and business loans. Using panel data for the nine (9) largest Greek banks over the period 2003Q1-2009Q3, they find that the GDP growth rate, the unemployment rate, the lending rates and the public debt exert a strong impact on NPLs. They also show that bank-specific variables that are related to the quality of management (specifically, cost efficiency and performance) are among the determinants of NPLs in Greece. Eventually, the results indicate that the quantitative effects of the various NPL determinants depend on the category of loans, with mortgages being the least affected by macroeconomic developments. Using a quasi-AIM (aggregating individual markets – AIM) approach on a panel of supervisory data from the nine (9) largest banks in Greece over the period 2003Q1-2009Q3, and distinguishing between consumer, mortgage and business loans, Vouldis and Louzis (2018) find that specific market variables (supermarket sales, confidence indices for the services and construction sector, and the business sentiment index) are good predictors for future NPLs. In addition, bank-level variables related to performance (inefficiency, ROA and ROE) represent top-performing leading indicators for business NPLs. Finally, industrial production and imports are the optimal predictors for consumer and business NPLs, respectively. In the same vein, Charalambakis et al. (2017) investigate the determinants of NPLs in Greece over the period 2005Q1-2015Q4 using aggregate data on consumer, mortgage and business loans. Using a SUR (seeming unrelated regressions) framework, suitably extended to allow for a common structural break in the relationship between NPLs and their determinants, they show that unemployment and inflation have been the key determinants of NPLs in the Greek banking sector, with their effects becoming stronger after the intensification of the recession and the political uncertainty in the first quarter of 2012.

In some other empirical studies, the research is based on individual loans. Using a dataset of corporate loans of 13070 Greek firms over the period 2008-2015, Asimakopoulos et al. (2016) find that one out of six firms with NPLs are strategic defaulters. They also note that the outstanding debt and the economic uncertainty are positively related to strategic default, while a negative relationship is documented between strategic default and the value of collaterals. Strategic default is also found to be more likely among medium-sized and middle-aged firms. Based on an extension of the discrete-time survival analysis model that allows for an endogenously estimated structural break in its baseline hazard function, Dendramis et al. (2018) model the probability of default of 79016 Greek individual mortgage loans with monthly frequency from January 2008 to October 2014. They show that political instability, economic recession and distressed financial conditions constitute the key factors for mortgage loan default. They also find that banning foreclosure laws on mortgage loans increase their probability of default by raising the moral hazard incentives that borrowers will not pay back their loans. Also, restructured or refinanced mortgage loans are found to positively affect future default probabilities. Finally, they provide evidence that the probability of default depends on loan-specific variables, such as the ratio of the total balance of a loan to its most recent collateral valuation and the ratio of the delinquent amount of a loan to its contract amount, as well as on macroeconomic variables, such as the unemployment rate and the inflation rate. Using a binomial logistic regression approach, Giannopoulos (2018) investigates the causes of NPLs in Greece by studying the status of a sample of 2591 loans granted to micro and small enterprises in order to cover their working capital needs. The loans were granted in 2005 and changes in their status are followed between December 2010 and December 2011. He finds that the age of the business's owner, the business loan to turnover ratio and the borrower's misbehavior before granting the loan have a positive impact on NPLs. In contrast, factors that indicate a higher wealth state of borrowers (e.g. existence of sufficient property free of liabilities), stronger collaterals and more years of business operation have a negative relationship with NPLs. Focusing on the probability of default of consumer loans Dendramis et al (2020) employ the skewed logit distribution as an asymmetric binary link function. They model the probability of default of 55805 Greek individual consumer loans with monthly frequency from April 2009 to December 2015. The skewed logit distribution considerably improves the ability of the underlying survival analysis model to predict the probability of default of consumer loans, especially under distressed financial conditions, compared to the logit and cloglog distributions. The results show that the ratio of the delinquent amount of a consumer loan over its balance constitutes a key indicator of loan default prediction, while the ratios of the installment and the actual payments of a loan over the personal income of the borrower reduce the probability of default, thus suggesting that the payment rates of consumer loans could increase if loan installments were adjusted to borrowers' income. In contrast, the total predictive power of macroeconomic covariates (GDP growth rate, unemployment rate and inflation rate) on the probability of loan default is small.

A group of studies examine the dynamic behavior of NPLs and other economic variables using a Vector Autoregressive (VAR) and a Vector Error Correction (VEC) approach. Konstantakis et al. (2016) investigate the determinants of NPLs in the Greek banking sector over the period 2001Q4-2015Q1. Using aggregate data and following a VAR/VEC approach, they find that the public debt exerts a strong positive impact on NPLs, indicating that fiscal problems in Greece are related to the increase of NPLs. They also find that rising NPLs are transmitted to the Greek economy through increases in unemployment. A VAR/VEC approach is also used by Monokroussos et al. (2016) to investigate the determinants of NPLs in Greece over the period 2005Q1-2015Q4. They find that a slowdown in economic activity and a rise in unemployment increase NPLs. They also consider that the primary cause of the sharp increase of NPLs in Greece after the outbreak of the 2008 crisis can primarily be explained by the huge decline in economic activity and the sharp rise in unemployment rather than by the rapid credit expansion experienced in Greece after the adoption of the euro. The degree of correlation of NPLs among the four systemic banks in Greece (National Bank of Greece, Alpha Bank, Piraeus Bank and Eurobank) over the period 2005-2016 is examined by Toudas et al. (2017). By employing a VAR/VEC approach, they find that the level of NPLs of each bank is affected not only by the performance of the bank itself in previous periods, but also by the performance of the other banks during the same periods. Furthermore, by examining the impulse response of a positive shock on the level of NPLs of each bank they expose the existence of correlations between the four banks.

Except for the NPL ratio alternative proxies for credit risk are also used in the empirical literature on the Greek banking system. Makri (2015) examines the effect of various accounting and macroeconomics indices on credit risk, proxied alternatively by the loans loss provisions (LLP) and loans loss reserves (LLR) ratios. Using two different datasets, the first containing individual bank level annual data over the period 2000-2011 and the latter containing aggregate quarterly data from 2001Q1 to 2012Q4, the study shows that unemployment, public debt and inflation exert a positive effect on credit risk, while the growth rate of GDP exerts a negative effect. In addition, higher levels of capital ratios, liquidity and profitability are found to improve the quality of the loan portfolio of banks.

Moreover, the quality of governance has been introduced in the empirical literature to assess its impact on NPLs. Anastasiou et al. (2019a) construct a new governance index by obtaining the common factor that describes the joint variation of the six

Worldwide Governance Indicators (WGI) for Greece by conducting a principal component analysis (PCA). Using annual data for the period 1996-2016, they find that the new governance index has a statistically significant impact on NPLs. Inefficient governance as well as systemic liquidity risk have been found to increase NPLs.

Finally, the role of post-crisis changes in regulation in Greece has been discussed by Karafolas and Ktenidou (2019) who stress the role of over-indebtedness and the need for legal protection of businesses and households. A new bankruptcy law, as well as encouragement of out-of-court settlements have been rather ineffective initiatives in containing NPLs given the size of the economic recession.

3. Data and econometric model

3.1 Data description

We employ a dataset containing aggregated quarterly data for the period 2003Q1-2020Q2. Data have been obtained from the Bank of Greece, the Organisation for Economic Co-operation and Development (OECD), the Bank of International Settlements (BIS) and Eurostat.

3.2 Econometric model

Our analysis is based on the following baseline regression model:

$$y_t = \alpha_0 + \sum_{k=1}^{K} \alpha_k \, x_k + \epsilon_t \qquad (1)$$

where y_t is the dependent variable, x_κ (κ=1,2,..,K) is a set of K macroeconomic or bank-related independent variables, and ε_t is the error term.

3.3 Regression variables

The dependent variable is the growth rate of the NPL ratio (*NPL*), which is often used in the literature as a proxy for credit risk.

The country-related factors taken into account in our estimations are the following:

The real GDP growth rate (*GDP*) shows the fluctuations in economic activity. During economic recessions, borrowers' incomes decrease hindering their ability to service their debt. The negative relationship between the GDP growth and the NPL ratio has been documented in the literature (Beck et al., 2015; De Bock and Demyanets, 2012; Jakubik and Reininger, 2014; Jimenez and Saurina, 2006; Karadima and Louri, 2021). Most researchers agree that it is the most important factor in determining NPLs.

The growth rate of the public (government) debt as percent of GDP (*PublicDebt*) is used in the literature as a proxy for a country's solvency risk. Reinhart and Rogoff (2010) note that the "sovereign ceiling", in which corporate borrowers are rated no higher than their national governments, places a threshold on the rating of a country's banks, making their offshore borrowing very costly or impossible. Under the pressure of reduced liquidity, banks may have to cut lending and thus borrowers cannot refinance their debts (Ghosh, 2015; Islamoglu, 2015). In addition, a high public debt may necessitate the need for fiscal measures, which as Gosh (2015) notes, may have a direct or indirect negative impact on borrowers' income and lead to a subsequent rise in NPLs. A positive impact of the public debt to GDP ratio on NPLs has also been reported by Ari et al. (2019), Koju et al. (2018), Louzis et al. (2012), and Vogiazas and Nikolaidou (2011).

The inverse of the employment expectations indicator (EEI), compiled by the Eurostat, is used to take into account unemployment uncertainty (*Unemployment*). As it has been supported by empirical studies (Dua and Smyth, 1993; Tortorice, 2012), people usually expect higher unemployment rates than those that are actually experienced in the future. It is the fear about future unemployment that may lead borrowers to postpone their loan payments. Also, if unemployment fears materialize, borrowers will be unable to service their debts and, hence, meet their debt obligations.

The fiscal balance (government budget balance) as percent of GDP (*FiscalBalance*) is used as a measure of a government's ability to meet its financing needs. Anastasiou et al. (2019b) find that fiscal deficits have a significantly positive impact on NPLs in the euro-area periphery countries during the period 1990Q1-2015Q2, implying a positive feedback between expansive fiscal policies and NPLs.

The quarterly growth rate of the Consumer Price Index (CPI) is used a proxy for the inflation rate (*Inflation*). According to Klein (2013), the impact of inflation on NPLs may be ambiguous, since higher inflation reduces both the real value of outstanding loans and the borrowers' real income. Under these conditions, loan servicing would be easier for borrowers, unless their wages remained sticky.

As for bank-related factors the following variables are used:

The growth rate of bank credit (provided to non-financial corporations) as percent of GDP (*BankCredit*) is used as a proxy for financial development. An increase in bank credit generally indicates a sound process of financial development. However, an excessive loan growth is often coupled with lower lending standards and collateral requirements, a practice that results in loan losses during economic downturns.

Borio and Lowe (2002a) argue that sustained rapid credit growth, combined with large increases in asset prices, appears to increase financial instability, while Jimenez and Saurina (2006) find that rapid credit growth results in lower credit standards eventually leading to higher NPLs. Kohler (2012) finds that banks become more risky if aggregate credit growth is excessive, whereas Aikman et al. (2015) note that a lesson of both past financial crises and the most recent global financial crisis is that credit booms sow the seeds of subsequent credit crunches. In the same vein, Cotugno et al. (2010), and Jakubik and Reininger (2014) find a positive impact of the bank credit to GDP ratio on NPLs.

To take into account possible long-term changes of the credit-to-GDP ratio, for example due to financial deepening (Drehmann et al., 2010), we also use the growth rate of the credit-to-GDP gap (*CreditGap*) as an alternative measure of credit growth. The credit-to-GDP gap, defined as the deviation of the credit-to-GDP ratio from its long-term trend, was first introduced by Borio and Lowe (2002b). They argue that when the credit-to-GDP ratio is sufficiently above its long-term trend financial imbalances emerge, which signal the risk of future distress.

The ratio of net loans to total assets (*Loans_to_Assets*) indicates the specialization of banks in providing loans. Brei et al. (2018) find that banks that are more involved in lending report relatively more NPLs, while Klein (2013) finds that the loans-to-assets ratio, considered as a proxy for excessive lending, leads to higher NPLs. A positive impact of the loan-to-asset ratio on NPLs has also been documented in Ekanayake and Azeez (2015), Khemraj and Pasha (2009), and Sinkey and Greenwalt (1991).

The growth rate of the 3-month interbank rate (*InterbankRate*) approximates the stance of monetary policy. Using 18000 annual observations on euro area banks over the period 2001-2008, Delis and Kouretas (2011) discover a strong negative relationship between interest rates and bank risk-taking. This finding holds for both short-term interest rate, proxied by the annual average of the 3-month interbank rate, and other types of interest rates (long-term, industry and bank-level). As the authors note, banks appear to have increased their risk-taking appetite substantially during the low interest rates period under study. Based on the detailed answers of the confidential Bank Lending Survey (BLS) for the euro area countries over the period 2002Q4-2008Q3 and of the Senior Loan Officer (SLO) survey for the U.S. over the period 1991Q2-2008Q3, Maddaloni and Peydro (2011) find that low (monetary policy) short-term interest rates soften the lending standards for household and corporate loans.

The growth rate of the interest rate spread (*InterestRateSpread*), which is the spread between loan and deposit rates, quantifies the efficiency of financial intermediation. As Agapova and McNulty(2016) note, low interest rate spreads are indicative of a more efficient financial system. Higher interest rate spreads increase the cost of loans charged on borrowers, so a positive impact of the growth of interest rate spreads on NPLs is expected (Espinoza and Prasad, 2010).

We allocate the above variables into four groups (see Table 1) in order to investigate the existence of a long-run relationship between the members of each group. Each variable may participate in more than one group, while the dependent variable *NPL* is a member of all four groups.

Table 1. Groups of variables

Group 1	**Group 2**	**Group 3**	**Group 4**
NPL	*NPL*	*NPL*	*NPL*
GDP	*GDP*	*GDP*	*GDP*
PublicDebt	*PublicDebt*	*FiscalBalance*	*FiscalBalance*
Unemployment	*Unemployment*	*CreditGap*	*Inflation*
BankCredit	*Loans_ to_ Assets*	*Inflation*	*InterbankRate*
			InterestRateSpread

4. Econometric methodology

4.1 Selection of econometric methodology

In this study, we investigate empirically the long-run equilibrium relationship between the dependent variable (*NPL*) and each of the sets of independent variables belonging to the groups presented in Table 1. This kind of analysis is usually based on the use of cointegration techniques, the most widely employed of which are those of Engle and Granger (1987), and Johansen (1991, 1992, 1995). However, these methods can be applied only in cases where all the underlying variables are integrated of order one. Therefore, none of the aforementioned techniques could be used in the context of our study, which is based on a mixture of both I(1) and I(0) variables, i.e. integrated of order one and zero, respectively. As a consequence, we decided to use a bounds testing approach, within the autoregressive distributed lag (ARDL) framework proposed by Pesaran et al. (2001). This methodology can be applied irrespective of whether the underlying variables are I(1), I(0), or a mixture of both. Because of this, the concept of long-run relationship established in this framework is much broader than that of cointegration.

In the context of the ARDL bounds testing approach, we express Equation (1) in the following unrestricted error correction (EC) model.

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p-1} \beta_{y,i}\, \Delta y_{t-i} + \sum_{k=1}^{K} \sum_{i=0}^{q_k-1} \beta_{k,i}\, \Delta x_{k,t-i} + \gamma_y y_{t-1} + \sum_{k=1}^{K} \gamma_k\, x_{k,t-1} + u_t \quad (2)$$

where Δ is the difference operator and u_t is the error term.

The coefficients attached to the differenced variables represent the short-run effects, while the values of the coefficients γ_k, after being divided by $-\gamma_y$, represent the long-run effects. The superscripts p and q_k (k=1,2,...,K) on the summation symbols in Equation (2) denote number of lags, which are optimally selected using one or more information criteria (BIC, AIC, etc.).

The proposed tests by Pesaran et al. (2001) are based on the standard F- and t-statistics. First, the F-statistic is used to test the null hypothesis (H_0) that the values of the coefficients γ_y and γ_k (k=1,2,…,K) are jointly zero (i.e. $\gamma_y=\gamma_1=\gamma_2=\ldots=\gamma_K=0$), suggesting the absence of a long-run relationship, against the alternative hypothesis (H_1) that at least one of these coefficients differs from zero. However, as Narayan (2005) notes, the F-statistic has a non-standard distribution, which depends upon (a) whether the variables are I(0) or I(1), (b) the number of regressors, (c) whether the model includes an intercept and/or trend, and (d) the sample size.

For this reason, Pesaran et al. (2001) provide two sets of critical values for the F-statistic, one that assumes that all variables are I(0) and another one that assumes that all variables are I(1). The critical values for the I(0) and the I(1) variables are considered as the lower bound and the upper bound critical values, respectively. If the F-statistic falls below the lower bound, the H_0 hypothesis cannot be rejected. Hence, we conclude that the variables cannot be in a long-run relationship. If the F-statistic falls between the two bounds, the bounds F-test is inconclusive. Finally, if the F-statistic exceeds the upper bound, then the H_0 hypothesis is rejected.

However, the rejection of the null hypothesis (H_0) solely cannot guarantee the existence of long-run relationship, since the alternative hypothesis H_1 permits two cases, referred by Pesaran et al. (2001) as "degenerate level relationships", which imply no long-run relationship between the dependent variable and the independent variables.

(a) $\gamma_y=0$, but at least one of $\gamma_1, \gamma_2, \ldots, \gamma_K$ is different from zero.

(b) $\gamma_y\neq0$, but $\gamma_1=\gamma_2=\ldots=\gamma_K=0$.

To rule out the degenerate case (a), we use the t-statistic to test the null hypothesis of a zero coefficient of the lagged dependent variable (H_0:γ_y=0 against H_1:γ_y<0). As in the case of the F-statistic, Pesaran et al. (2001) provide two sets of critical values for the t-statistic, one that assumes that all variables are I(0) and another that assumes that all variables are I(1). The lower critical value bound is obtained when all variables are purely I(0), while the upper critical values bound is obtained when all variables are purely I(1). If the t-statistic falls below its lower bound, we cannot reject H_0. If the t-statistic falls between its upper and lower bound, the bounds t-test is inconclusive. Finally, if the t-statistic exceeds its upper bound, we can conclude that the coefficient of the lagged dependent variable is statistically different from zero, thus providing evidence that the degenerate case (a) can be ruled out.

The ruling out of the degenerate case (b) can be checked by conducting conventional Wald tests in order to test the null hypothesis (H_0) that the long-run coefficients of the independent variables (i.e. $\theta_1=-\gamma_1/\gamma_y$, $\theta_2=-\gamma_2/\gamma_y$,…,$\theta_K=-\gamma_K/\gamma_y$) are jointly zero. The use of θ_i (i=1,2,…,K) in this test constitutes a practical advantage over tests directly based on the coefficients γ_i (i=1,2,…,K) of Equation (2), since the latter have non-standard distributions (Kripfganz and Schneider, 2020).

To summarize, we can conclude that there is a long-run relationship between the dependent and the independent variables if and only if all the above three tests reject their respective null hypotheses (H_0). It should also be noted that if the dependent variable were I(1) then there could be at most one cointegrating relationship involving the dependent variable (Pesaran et al., 2001).

4.2 Implementation of the selected econometric methodology

First, the Augmented Dickey-Fuller (ADF) unit-root tests showed that none of our variables had an order beyond unity. More specifically, the variables *Loans_to_Assets* and *Inflation* were found to be I(1), while the other variables were found to be I(0).

Second, all the regressions were performed using the ardl.ado program, developed in Stata by Kripfganz and Schneider (2018). The results are presented in Table 2. Models 1-4 correspond to the groups of variables 1-4 (see Table 1) respectively. The optimal number of lags for each variable and per model among all possible combinations of up to a maximum of 6 lags was selected using the Bayesian information criterion (BIC).

Regarding the bounds test, the ardl.ado program uses the critical values that have been computed by Kripfganz and Schneider (2020) who use response surface regressions to obtain finite-sample and asymptotic critical values, which allow for any number of long-forcing variables. These critical values fit well to our small-size sample as the critical values provided by Pesaran et al. (2001) have been generated for large samples. Following the results of the bounds test as presented in Table A3 in the Appendix, the values of the F-statistic and the t-statistic across all models indicate a long-run relationship between the dependent variable *NPL* and the independent variables included in each model.

The results of the Wald tests, which were conducted to check the degenerate case (b) in Section 4.1, are presented in Table A4 in the Appendix. Based on the results of all three tests (i.e. the F-bounds test, the t-bounds test, and the Wald test) we can definitely conclude that there exists a long-run relationship between the dependent variable *NPL* and the independent variables across all models 1-4.

We also conducted a set of post-estimation checks in order to assess the validity of our regression results: the Breusch-Pagan / Cook-Weisberg test for heteroscedasticity, the Breusch-Godfrey LM test and the Durbin's alternative test for autocorrelation, the skewness/kurtosis test and the Shapiro-Wilk W test for normality, the Ramsey RESET (Regression Specification-Error Test) for omitted variables, and the cumulative sum (CUSUM) test for parameter stability. The results of these tests are presented in Table A4 in the Appendix.

Table 2. NPL regression models

VARIABLES	Model 1	Model 2	Model 3	Model 4
Adjustment to equilibrium				
NPL(-1)	-0.688***	-0.657***	-0.512***	-0.535***
	(0.105)	(0.107)	(0.080)	(0.078)
Long-run relationship				
GDP (-1)	-1.965***	-1.809***	-3.355***	-3.347***
	(0.601)	(0.642)	(0.620)	(0.575)
PublicDebt (-1)	0.916***	0.905**		
	(0.333)	(0.361)		
Unemployment (-1)	0.178**	0.181**		
	(0.078)	(0.084)		
FiscalBalance (-1)			-0.338**	-0.308**
			(0.163)	(0.152)
Inflation (-1)			0.528	0.122

VARIABLES	Model 1	Model 2	Model 3	Model 4
			(1.670)	(1.561)
BankCredit (-1)	0.042			
	(0.268)			
CreditGap (-1)			0.012	
			(0.010)	
Loans_to_Assets (-1)		0.063		
		(0.124)		
InterbankRate (-1)				-0.027*
				(0.014)
InterestRateSpread (-1)				0.242*
				(0.129)
Short-run relationship				
Δ*GDP*	-0.261	-0.011	-0.325*	-0.268
	(0.239)	(0.212)	(0.170)	(0.166)
Δ*PublicDebt*	0.062	0.097		
	(0.130)	(0.133)		
Δ*PublicDebt* (-1)	-0.338***	-0.313**		
	(0.119)	(0.122)		
Δ*Unemployment*	0.140	0.139		
	(0.087)	(0.090)		
Δ*Unemployment* (-1)	0.314***	0.292***		
	(0.087)	(0.090)		
Δ*FiscalBalance*			0.212**	0.196**
			(0.094)	(0.091)
Δ*Inflation*			-1.591**	-1.414**
			(0.647)	(0.626)
Δ*Inflation* (-1)			-0.577	-0.141
			(0.987)	(0.999)
Δ*Inflation* (-2)			-0.840	-0.051
			(0.879)	(0.928)
Δ*Inflation* (-3)			-3.532***	-3.153***
			(0.814)	(0.793)
Δ*Inflation* (-4)			-1.661**	-1.345*
			(0.715)	(0.708)
Δ*BankCredit*	-0.611*			

VARIABLES	Model 1	Model 2	Model 3	Model 4
	(0.310)			
ΔCreditGap			0.006	
			(0.005)	
ΔLoans_to_Assets		0.041		
		(0.082)		
ΔInterbankRate				-0.015*
				(0.007)
ΔInterestRateSpread				0.129*
				(0.067)
Constant	9.683	6.568	-0.754	-1.628
	(6.551)	(8.185)	(2.359)	(2.321)
Observations	64	64	64	64
R-squared	0.761	0.740	0.781	0.798
Adj. R-squared	0.692	0.672	0.712	0.729

Notes: **Dependent variable: Δ*NPL***. The symbols *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels respectively. Standard errors are reported in parentheses. Δ is the first difference operator, while (-n) represents the n-th lag (n=1,2,3,4).

5. Empirical results

The results of the econometric estimation of our regression models are presented in Table 2. We first go through the results regarding the long-run relationship between the variables under examination and then we comment on their short-run dynamics. The most reliable determinants of NPLs are related to macroeconomic developments (growth, public debt, fiscal balance, unemployment uncertainty). Some bank-related variables play a less significant role.

5.1 Adjustment to equilibrium

As it is shown in Table 2, the coefficient of adjustment (provided by the opposite of the coefficient of the first lag of the dependent variable) is positive as it should be in order to have convergence towards the long-run equilibrium after a shock. The coefficient of adjustment denotes how much of the adjustment to equilibrium takes place in each period. For example, the coefficient of adjustment in Model 1 is equal to -(-0.688)=0.688, which denotes that 68.8% of the adjustment takes place each quarter.

5.2 Long-run effects

As expected, the real GDP growth (GDP) exerts a statistically significant and negative impact on NPLs across all models 1-4. As has already been supported by other researchers economic growth usually translates into higher income, which improves the financial capacity of borrowers.

The coefficient of the public debt growth rate (PublicDebt) is positive and statistically significant (Models 1-2). The sharp and continuing increase of the Greek public debt after the first quarter of 2009 fueled fears about sovereign solvency and about the need to introduce austerity measures aiming at improving debt sustainability. Such fears make people and enterprises insecure and willing to postpone or even cancel their loan repayments. They also create financing difficulties for banks, which cannot roll over existing loans to enterprises. Debt servicing comes to a standstill and NPLs increase.

The uncertainty about future unemployment (Unemployment) exerts a positive and statistically significant impact on NPLs (Models 1-2). It is the fear about future unemployment that makes debtors likely to delay their loan payments or even to suspend them completely.

The coefficient of fiscal balance (FiscalBalance) is negative and statistically significant (Models 3-4). A fiscal surplus may give the opportunity to the government to increase the public spending and investment, stimulating the economic activity and leading to a subsequent reduction of NPLs. In contrast, a fiscal deficit may force the government to take austerity measures that would have an adverse impact on households and firms' income, thus increasing NPLs. Fiscal balance remained steadily negative (i.e. in deficit) from the starting period of our study (2003Q1) until 2016Q1, ranging between -30,7% and -8% with an average value of -8.7%.

The coefficient of the last macroeconomic variable used (Inflation) is positive but not statistically significant (Models 3-4). As has been suggested in other studies (Us, 2017, 2018) rising prices in the long-term reduce the available income of borrowers and may make the repayment of their loans more difficult. Hence, commitment to price stability is important for containing NPLs and, subsequently, promoting financial stability. In our case, though, it was not found to exert a significant long-term effect on NPLs.

The coefficients of the three bank-specific variables although they had the expected positive signs were not found to be significant. The growth rate of bank credit

(BankCredit) was found to have a positive sign (Model 1). As explained in the literature an increase in bank credit generally indicates a sound process of financial development. However, an excessive loan growth is often coupled with lower lending standards and collateral requirements, a practice that pops up as loan losses during economic downturns. Bank credit in Greece exceeded 100% of GDP in 2008Q3, reaching a peak of 119% in 2012Q2. A similar positive sign was obtained for the growth rate of credit gap (CreditGap) in Model 3, suggesting that any deviations of the credit-to-GDP ratio from its long-term trend were not so big as to have a significant impact on NPLs in the long run. Finally, the coefficient of the loans to assets ratio (Loans_to_Assets) in Model 2 was positive indicating that banks with high loans to assets ratios incur higher levels of NPLs due to selecting riskier projects as they increase the number of loans. Still, all three estimated coefficients corresponding to bank-related characteristics were not statistically significant.

Finally, the last two variables taking into account the variability of interest rates were found to exert statistically significant long-term effects on NPL growth. The coefficient of the interbank rate (InterbankRate) is negative and significant at the 10% significance level (Model 4), suggesting that an increase in interbank rates may lead banks with surplus money to invest in the interbank money market rather than provide risky loans. Conversely, declining interbank rates may make them so attractive to banks with a high risk profile as to lead them to borrow funds in the interbank market and invest them in riskier loans. The coefficient of the interest rate spread (InterestRateSpread) is positive and statistically significant at the 10% significance level (Model 4), indicating that higher spreads between deposit and loan rates increase the cost to borrowers and, thus, lead to higher growth of NPLs.

5.3 Short-run effects

The coefficient of the variable Δ*GDP* is negative across all models 1-4, but statistically significant (at the 10% level) only in Model 3. These findings suggest that a shock to the rate of change of the economic activity does not have a significant contemporaneous impact on NPLs.

The coefficient of the variable Δ*PublicDebt(-1)*, representing the one-period delayed effect of an increase in public debt, is statistically significant and negative in Models 1 and 2. An increase in public debt, directed towards public spending, can promote lending activity and lead to a temporary decrease of NPL ratios through the denominator effect. The fact that the public debt does not affect NPLs contemporaneously (the coefficient of the variable Δ*PublicDebt* is not statistically significant and positive) indicates that capital flows may need some time to be directed to the real economy.

A statistically significant and positive one-period delayed effect on NPLs is noticed in the case of unemployment uncertainty (Δ*Unemployment (-1)*) in Models 1 and 2, while unemployment uncertainty does not appear to significantly affect NPLs contemporaneously. These findings suggest that the effects of changes in the uncertainty about future unemployment may take some time to materialize in the form of failures in loan repayments.

The coefficient of fiscal balance (*FiscalBalance*) is positive and statistically significant across both Models 3 and 4. An improvement in fiscal balance, stemming from increased tax collections in a specific quarter or a reduction in public spending, may lead some borrowers to postpone their loan payments.

Some noteworthy effects of inflation on NPLs, either being contemporaneous or coming from three and four quarters back, are indicated by the negative and statistically significant coefficients of the variables Δ*Inflation*, Δ*Inflation*(-3) and Δ*Inflation*(-4), respectively. We assume that the contemporaneous effect is coming from the banks' side, since an increase in the inflation rate drives down their real rate of return and may lead them to temporarily reduce lending and even introduce stricter lending standards. The delayed effect might come from the borrowers' side, since the reduction in the real value of loan installments may make their payments easier at least for a while.

Regarding the bank-related determinants, the coefficient of bank credit (*BankCredit*) in Model 1 is statistically significant and negative, indicating that in the short-run an increase in bank credit reduces the NPL ratio. This short-run reaction of the NPL ratio can be attributed to the denominator effect. In contrast, the negative coefficient of the credit gap (*CreditGap*) is not statistically significant, indicating that any deviations of the credit-to-GDP ratio from its long-term trend were not found to have a significant short-run impact on NPLs. Finally, the short-run coefficient of the *Loans_to_Assets* variable is estimated to be positive but not statistically significant, suggesting that the specialization of banks in providing loans cannot be considered as a factor that played a major role in increasing NPLs.

Lastly, the short-term effects of the interbank rate (*InterbankRate*) were found to be negative and statistically significant at the 10% significance level (Model 4) as in the long-term estimations. The explanation is similar, i.e. an increase in interbank rates may lead banks with surplus funds to invest in the interbank money market rather than provide risky loans. Likewise, the coefficient of the interest rate spread (*InterestRateSpread*) is positive and statistically significant at the 10% significance level (Model 4) as in the long-term estimations. Higher spreads between deposit and loan rates increase the cost to borrowers and make the servicing of loans more difficult leading to higher growth of NPLs.

6. Conclusions

Following the financial and debt crises in the euro area and the delays in formulating a cohesive policy response, banks in Greece faced serious problems with the increase in non-performing loans (NPLs) being the most threatening and the most serious among euro area economies.

In this study, we attempted to empirically investigate the determinants of NPLs in the Greek banking sector, using quarterly aggregate data for the period 2003Q1-2020Q2 and the autoregressive distributed lag (ARDL) bounds testing approach. We found that NPLs are determined mostly by factors related to macroeconomic conditions in Greece (GDP growth, public debt, fiscal balance and unemployment uncertainty) during the period under investigation, rather than by bank-related factors. Only the interbank interest rate and the spreads between deposit and loan rates as set by banks were found to affect NPLs significantly.

Of particular interest is the case of government debt, which is found to exert a significant and positive long-term impact on NPLs irrespective of some short-term dynamics that appear to provide a temporary relief. The fiscal balance is also found to exert a negative long-term effect, justifying the quest for surpluses post-crisis. As debt accumulation is a policy followed by most countries in order to stabilize economies hit by the COVID-19 crisis, its long-term effects on the financial system and, more specifically, on NPLs should be taken into account. In the Greek case drastic institutional measures, such as the creation of an asset management company or the introduction of new government guaranteed securitization schemes could be the major (if not the only) weapon to face the risk.

References

Agapova, A., and McNulty, J. (2016). Interest rate spreads and banking system efficiency: General considerations with an application to the transition economies of Central and Eastern Europe. *International Review of Financial Analysis*, 47, 154-165.

Aikman, D., Haldane, A., and Nelson, B. (2015). Curbing the Credit Cycle. *The Economic Journal*, *125*(585), 1072–1109.

Anastasiou, D., Louri, H., and Tsionas, M. (2016). Determinants of nonperforming loans: Evidence from Euro-area countries. *Finance Research Letters*, 18, 116–119.

Anastasiou, D., Bragoudakis, Z., and Malandrakis, I. (2019a). Non-performing loans, governance indicators and systemic liquidity risk: evidence from Greece. Working Paper No. 160, Bank of Greece.

Anastasiou, D., Louri, H., and Tsionas, M. (2019b). Non-Performing Loans in the Euro-area: Are Core-Periphery Banking Markets Fragmented? *International Journal of Finance and Economics, 24*(1), 97-112.

Anginer, D., Demirguc-Kunt, A., and Zhu, M. (2014). How does competition affect bank systemic risk? *Journal of Financial Intermediation,* 23*,* 1–26.

Ari, A., Chen, S., and Ratnovski, L. (2019). The Dynamics of Non-Performing Loans During Banking Crises: A New Database. Working Paper No. 272, International Monetary Fund.

Asimakopoulos, I., Avramidis, P., Malliaropulos, D., and Travlos, N. (2016). Moral Hazard and Strategic Default: Evidence from Greek Corporate Loans. Working Paper No. 211, Bank of Greece.

Bank of Greece (2020). Monetary Policy Interim Report, December 2020.

Bank of Greece (2021). Financial Stability Review. January 2021.

Beck, R., Jakubik, P., and Piloiu, A. (2015). Key Determinants of Non-performing Loans: New Evidence from a Global Sample. *Open Economies Review*, *26*(3), 525-550.

Borio, C., and Lowe, P. (2002a). Asset prices, financial and monetary stability: exploring the nexus. Working Paper No. 114, Bank for International Settlements.

Borio, C., and Lowe, P. (2002b). Assessing the risk of banking crises. *BIS Quarterly Review*, December, 43–54.

Brei, M., Jacolin, L., and Noah, A. (2018). Credit risk and bank competition in Sub-Saharan Africa. Working Paper No. 664, Banque de France.

Charalambakis E., Dendramis Y., and Tzavalis, E. (2017). On the Determinants of NPLs: Lessons from Greece. In I. Bournakis, C. Tsoukis, D. Christopoulos, and T. Palivos (Eds). Political Economy Perspectives on the Greek Crisis (pp. 289-309). Palgrave Macmillan, Cham.

Cotugno, M., Stefanelli, V., and Torluccio, G. (2010). Bank intermediation models and portfolio default rates: What's the relation? 23rd Australasian Finance and Banking Conference 2010, doi: 10.2139/ssrn.1662888.

D'Agostino, R., Belanger, A., and D'Agostino Jr., R. (1990). A suggestion for using powerful and informative tests of normality. *American Statistician, 44*(4), 316-321.

De Bock, R., and Demyanets, A. (2012). Bank Asset Quality in Emerging Markets: Determinants and Spillovers. Working Paper No. 12/71, International Monetary Fund.

Delis, M., and Kouretas, P. (2011). Interest rates and bank risk-taking. *Journal of Banking & Finance*, 35, 840–855.

Dendramis, Y., Tzavalis, E., and Adraktas, G. (2018). Credit risk modelling under recessionary and financially distressed conditions. *Journal of Banking and Finance***,** 91, 160-175.

Dendramis, Y., Tzavalis, E., Varthalitis, P., and Athanasiou, E. (2020). Predicting default risk under asymmetric binary link functions. *International Journal of Forecasting*, 36, 1039-1056.

Drehmann, M., Borio, C., Gambacorta, L., Jiménez, G., and Trucharte, C. (2010). Countercyclical capital buffers: exploring options. Working Paper No. 317, Bank for International Settlements.

Dua, P., and Smyth, D. (1993). Survey evidence on excessive public pessimism about the future behavior of unemployment. *Public Opinion Quarterly*, 57, 566–574.

Ekanayake, E., and Azeez, A.A. (2015). Determinants of nonperforming loans in licensed commercial banks: evidence from Sri Lanka. *Asian economic and Financial Review, 5*(6), 868-882.

Engle, R., and Granger, C. (1987). Cointegration and error correction representation: estimation and testing. *Econometrica,* 55, 251–276.

Espinoza, R., and Prasad, A. (2010). Nonperforming loans in the GCC banking system and their macroeconomic effects. Working Paper No. 224, International Monetary Fund.

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.

Giannopoulos, V. (2018). What Causes Non-Performing Loans? The Case of Greece Using Primary Accounting Data. *Open Journal of Accounting*, 7, 191-206.

Hardouvelis, G. (2021). Financial crisis and non-performing exposures in Greece. *GreeSE Discussion Paper* 159, Hellenic Observatory, LSE.

Islamoglu, M. (2015). The effect of macroeconomic variables on nonperforming loan ratio of publicly traded banks in Turkey. *Transactions on Business and Economics*, 12, 10-20.

Jakubik, P., and Reininger, T. (2014). What are the Key Determinants of Nonperforming Loans in CESEE? Working Paper No. 26, Institute of Economic Studies, Charles University Prague.

Jimenez, G., and Saurina, J. (2006). Credit Cycles, Credit Risk, and Prudential Regulation. *International Journal of Central Banking*, *2*(2), 65-98.

Johansen, S. (1991). Estimation and hypothesis testing of cointegrating vectors in Gaussian vector autoregressive models. *Econometrica,* 59, 1551–1580.

Johansen, S. (1992). Cointegration in partial systems and the efficiency of single-equation analysis. *Journal of Econometrics,* 52, 389–402.

Johansen, S. (1995). *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. Oxford University Press: Oxford.

Karadima, M., and Louri, H. (2020). Non-performing loans in the euro area: Does bank market power matter? *International Review of Financial Analysis*, 72, Article 101593.

Karadima, M., and Louri, H. (2021). Economic policy uncertainty and non-performing loans: The moderating role of bank concentration. *Finance Research Letters*, 38, Article 101458.

Karafolas, S., and Ktenidou, P. (2019). Non-performing loans in the Greek case: evolution and initiatives in the regulatory framework. *Transition Studies Review*, 26, 57-69.

Kauko, K. (2012). External deficits and non-performing loans in the recent financial crisis. *Economics Letters*, 115, 196-199.

Khemraj, T., and Pasha, S. (2009). The determinants of non-performing loans: an econometric case study of Guyana. MPRA Paper No. 53128, University Library of Munich.

Kick, T., and Prieto, E. (2015). Bank Risk Taking and Competition: Evidence from Regional Banking Markets. *Review of Finance, 19*(3), 1185-1222.

Klein, N. (2013). Non-Performing Loans in CESEE: Determinants and Impact on Macroeconomic Performance. Working Paper No. 13/72, International Monetary Fund.

Kohler, M. (2012). Which banks are more risky? The impact of loan growth and business model on bank risk-taking. Discussion Paper No. 33, Deutsche Bundesbank.

Koju, L., Koju, R., and Wang, S. (2018). Macroeconomic and Bank-Specific Determinants of Non-Performing Loans: Evidence from Nepalese Banking System. *Journal of Central Banking Theory and Practice,* 3*,* 111-138.

Konstantakis, K., Michaelides, P., and Vouldis, A. (2016). Non-performing loans (NPLs) in a crisis economy: Long-run equilibrium analysis with a real time VEC model for Greece (2001–2015). *Physica A*, 451, 149–161.

Kripfganz, S., and Schneider, D. (2018). ardl: Estimating autoregressive distributed lag and equilibrium correction models. London Stata Conference, September 7, 2018.

Kripfganz, S., and Schneider, D. (2020). Response Surface Regressions for Critical Value Bounds and Approximate p-values in Equilibrium Correction Models. *Oxford Bulletin of Economics and Statistics, 82*(6), 1456-1481.

Louri, H., and Migiakis, P. (2019). Financing economic activity in Greece: Past challenges and future prospects. *GreeSE Discussion Paper* 135, Hellenic Observatory, LSE.

Louzis, D., Vouldis., A., and Metaxas, V. (2012). Macroeconomic and bank-specific determinants of NPLs in Greece: A comparative study of mortgage, business and consumer loan portfolios. *Journal of Banking and Finance*, 36, 1012-1027.

Maddaloni, A., and Peydro, J.L. (2011). Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-area and the U.S. Lending Standards. *Review of Financial Studies*, *24*(6), 2121-2165.

Makri, V. (2015). What Triggers Loan Losses? An Empirical Investigation of Greek Financial Sector. *SPOUDAI Journal of Economics and Business, 65*(3-4), 119-143.

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

Monokroussos, P., Thomakos, D., and Alexopoulos, T. (2016). Explaining Non-Performing Loans in Greece: A Comparative Study on the Effects of Recession and Banking Practices. *GreeSE Discussion Paper* 101, Hellenic Observatory, LSE.

Narayan, P.K. (2005). The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics, 37*(17), 1979-1990.

Nkusu, M. (2011). Nonperforming Loans and Macrofinancial Vulnerabilities in Advanced Economies. Working Paper No. 11/161, International Monetary Fund.

Podpiera J., and Weill, L. (2008) Bad luck or bad management? Emerging banking market experience. *Journal of Financial Stability*, 4, 135–148.

Pesaran, M. H., Shin, Y., and Smith, R. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, 16*(3)*,* 289–326.

Reinhart, C., and Rogoff, K. (2010). From Financial Crash to Debt Crisis. Working Paper No. 15795, US National Bureau of Economic Research (NBER).

Rinaldi, L., and Sanchis-Arellano, A. (2006). Household debt sustainability: What explains household non-performing loans? An empirical analysis. Working Paper No. 570, European Central Bank.

Royston, P. (1991). sg3.5: Comment on sg3.4 and an improved D'Agostino test. *Stata Technical Bulletin*, 3, 23-24.

Sinkey, J., and Greenwalt, M., (1991). Loan-Loss Experience and Risk-Taking Behavior at Large Commercial Banks. *Journal of Financial Services Research*, 5, 43-59.

Tortorice, D. L. (2012). Unemployment expectations and the business cycle. *The B.E. Journal of Macroeconomics*, *12*(1), 1–47.

Toudas, K., Christopoulos, A., Kalantonis, P., and Kravaritis, S. (2017). The Correlation of Non-Performing Loans Between the Four Greek Systemic Banks Before and During the Recent Crisis Based on Accounting Information. *International Journal of Corporate Finance and Accounting, 4*(2), 23-40.

Us, V. (2017). A dynamic approach to analyzing the effect of the global crisis on nonperforming loans: evidence from the Turkish banking sector. *Applied Economics Letters*, *24*(3), 186-192.

Us, V. (2018). The determinants of nonperforming loans before and after the crisis: Challenges and policy implications for Turkish banks. *Emerging Markets Finance and Trade, 54*(7), 1608-1622.

Vithessonthi, C. (2016). Deflation, bank credit growth, and non-performing loans: Evidence from Japan. *International Review of Financial Analysis*, 45*,* 295-305.

Vogiazas, S., and Nikolaidou, E. (2011). Investigating the Determinants of Nonperforming Loans in the Romanian Banking System: An Empirical Study with Reference to the Greek Crisis. *Economics Research International*, Vol. 2011-Article ID 214689.

Vouldis, A., and Louzis, D. (2018). Leading indicators of non-performing loans in Greece: the information content of macro-, micro- and bank-specific variables. *Empirical Economics*, 54, 1187–1214.

Appendix

Table A1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
NPL	70	2.400	6.794	-12.690	18.957
GDP	70	-0.372	2.345	-14.148	3.258
PublicDebt	70	0.897	3.519	-19.582	9.827
Unemployment	70	-99.449	10.385	-116.200	-75.100
FiscalBalance	70	-6.629	6.313	-30.700	5.700
Inflation	70	0.373	1.393	-2.070	3.550
BankCredit	70	0.633	2.266	-5.379	4.762
CreditGap	70	3.299	75.698	-300.000	525.00
Loans to Assets	70	65.584	5.044	53.487	74.209
InterbankRate	70	4.820	54.536	-114.130	327.692
InterestRateSpread	70	-0.056	6.000	-13.232	16.024

Table A2: Correlation Matrix

Variable	NPL	GDP	Public Debt	Unemploy-ment Uncertainty	Fiscal Balance	Infla-tion	Bank Credit	Credit Gap	Loans _to_ Assets	Inter - bank Rate	Interest Rate Spread
NPL	1.000										
GDP	-0.279	1.000									
PublicDebt	0.195	-0.368	1.000								
Unemployment	0.707	-0.383	0.195	1.000							
FiscalBalance	-0.408	0.260	-0.296	-0.368	1.000						
Inflation	-0.101	0.054	0.190	-0.008	-0.247	1.000					-
BankCredit	0.023	-0.154	0.110	0.005	-0.444	0.333	1.000				
CreditGap	-0.070	0.072	-0.100	-0.032	0.102	-0.127	-0.065	1.000			
Loans_to_Assets	0.267	0.066	0.064	0.150	-0.375	0.288	0.618	-0.050	1.000		
InterbankRate	-0.120	0.040	0.046	-0.011	0.132	-0.093	-0.056	-0.082	-0.166	1.000	
InterestRateSpread	0.142	-0.054	0.297	-0.036	0.053	-0.255	-0.021	0.086	-0.099	0.329	1.000

Table A3: Bounds test

			Critical values (at 5%)	
Model No.	**F-statistic**	**t-statistic**	**I(0)**	**I(1)**
1	11.576		2.986	4.358
		-6.570	-2.838	-3.979
2	10.122		2.994	4.350
		-6.156	-2.843	-3.986
3	8.284		3.019	4.326
		-5.412	-2.861	-4.006
4	11.622		2.977	4.366
		-6.369	-2.832	-3.972

Table A4. Other post-estimation tests

Test	Null hypothesis	Model No.	p-value	t-value	Critical value (at 5%)
Wald test	Long-run coefficients of independent variables are jointly zero	1	0.0000		
		2	0.0000		
		3	0.0000		
		4	0.0000		
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	Constant variance	1	0.3935		
		2	0.3607		
		3	0.9939		
		4	0.5267		
Breusch-Godfrey LM test for autocorrelation	No serial correlation	1	0.1902		
		2	0.2918		
		3	0.9165		
		4	0.8693		
Durbin's alternative test for autocorrelation	No serial correlation	1	0.2502		
		2	0.3521		
		3	0.9284		
		4	0.8890		
Skewness and kurtosis joint test for normality (*)	Normality	1	0.0672		
		2	0.0635		
		3	0.3775		
		4	0.1972		
Shapiro-Wilk W test for normal data	Normality	1	0.1080		
		2	0.0766		
		3	0.3075		
		4	0.2339		
Ramsey RESET (Regression Specification-Error Test) for omitted variables	Model has no omitted variables	1	0.5278		
		2	0.3421		
		3	0.7344		
		4	0.5831		
Cumulative sum (CUSUM) test for parameter stability	No structural break	1		0.9048	0.9479
		2		0.8857	0.9479
		3		0.4155	0.9479
		4		0.6131	0.9479

* D'Agostino, Belanger and D'Agostino Jr. (1990) test, with the adjustment made by Royston (1991).

Previous Papers in this Series

159. **Gikas A. Hardouvelis,** Financial Crisis and Non-performing Exposures in Greece, May 2021

158. **George Alogoskoufis,** Historical Cycles of the Economy of Modern Greece from 1821 to the Present, April 2021

157. **Vassilis Arapoglou, Nikos Karadimitriou, Thomas Maloutas and John Sayas**, Multiple Deprivation in Athens: a legacy of persisting and deepening spatial division, March 2021

156. **Georgios Gatopoulos, Alexandros Louka, Ioannis Polycarpou and Nikolaos Vettas,** Evaluating the Impact of Labour Market Reforms in Greece during 2010-2018, February 2021

155. **Athanasios Kolliopoulos,** Reforming the Greek Financial System: a decade of failure, January 2021

154. **Konstantinos Dellis,** Knowledge Diffusion and Financial Development Thresholds, December 2020

153. **Charalambos Tsekeris, Nicolas Demertzis, Apostolos Linardis, Katerina Iliou, Dimitra Kondyli, Amalia Frangiskou and Olga Papaliou,** Investigating the Internet in Greece: findings from the World Internet Project, November 2020

152. **George Economides, Dimitris Papageorgiou and Apostolis Philippopoulos,** Macroeconomic policy lessons for Greece, October 2020

Special Issue edited by Vassilis Monastiriotis and Philipp Katsinas, The Economic Impact of COVID-19 in Greece, September 2020

151. **Sotiris K. Papaioannou,** Political Instability and Economic Growth at Different Stages of Economic Development: historical evidence from Greece, August 2020

150. **Eirini Andriopoulou, Eleni Kanavitsa, Chrysa Leventi and Panos Tsakloglou,** The Distributional Impact of Recurrent Immovable Property Taxation in Greece, July 2020

149. **Eirini Andriopoulou, Eleni Kanavitsa and Panos Tsakloglou,** Decomposing Poverty in Hard Times: Greece 2007-2016, June 2020

148. **Athanasios Kolliopoulos,** The Determinants of Bank Bailouts in Greece: testing the extreme limits of the "Varieties of Financial Capitalism" framework, May 2020