

Predictive Credit Risk Models incorporating Macro Factors for the Greek Banking Sector

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Abstract

This study aims to develop models of credit portfolio risk prediction for the Greek banking sector by incorporating key macroeconomic factors through empirical analysis.

Aggregate data on the evolution of Non-Performing Loans (NPLs) have been collected from the four (4) Systemic Banks and over a period of at least 10 years 2007 -2017.

These data will be utilized either to calibrate well known modern models or to construct new ones applying mainly linear approach (the two dimensions being time and loan) adding macroeconomic and other crucial indicator indices that affect credit risk.

The variables to be used are two types: a) bank and credit risk specific b) macroeconomic variables that affect the credit cycle. Macroeconomic variables include GDP growth rate, unemployment rate, real interest rate, Consumption growth, etc. and portfolio specific include change in non-performing loans to the total loan portfolio, impairment provisions towards total loans etc.

Based on this data the models constructed among others forecasted the evolution of non-performing loans throughout the business cycle.

Keywords: Credit Risk, Banking, NPLs, Macro Factors, Macro-econometrics

Introduction

Exploring the determinants of ex post credit risk is a matter of major importance for regulators dealing with financial stability and bank management. Ex-post credit risk takes the form of non-disbursed loans (non-performing loans). Reinhart and Rogoff (2010) point out that non-performing loans can be used to signal the start of a banking crisis.

This research topic, obviously very crucial for the banking sector, has been examined in other countries and in the majority of studies investigating the determinants of non-performing loans, the overall level of non-performing loans is taken into account, and macroeconomic or bank-specific determinants are used as explanatory variables.

Salas and Saurina (2002), which combine macroeconomic and microeconomic variables to explain the total non-performing loans of Spanish Commercial and Savings Banks for the

period 1985-1997. They focus on the NPLs for commercial banks and savings banks and find that the bank's determinants can serve as indicators of early warning for future changes to non-performing loans.

Most empirical studies address the impact of the macroeconomic environment on non-performing loans. Rinaldi and Sanchis-Arellano (2006) analyze non-performing households for a group of European countries and provide empirical evidence that disposable income, unemployment and monetary conditions have a strong impact on non-performing loans. Berge and Boye (2007) find that problematic loans are particularly sensitive to real interest rates and unemployment for the Scandinavian banking system over the period 1993-2005.

Boss et al. (2009) examines the correlation of the credit risk of the main Austrian corporate sectors with the business cycle. Other study that focus on the macroeconomic determinants of NPL include Nkusu (2011).

Conclusions of the entire analysis and suggestions for the future of the banking sector will be presented. These will involve the determination and their relative weight of the key drivers for the evolution of non-performing loans as well as prediction of the state of the various portfolios in relation to the state of the Greek Economy. Finally, these results will provide the means for more efficient calculation of credit risk provisions and capital ratios and the future state of loan portfolios and will be useful not only for Banks but also for European Regulators or for those that audit and control the Greek Banking Sector.

Presentation of the sample and model

The sample

The sample consists of 4 Systemic Banks in Greece for a period of 10 years (2007-2017). The choice of Greece is not accidental as it is a representative country facing problems after the 2007 crisis and worsening public finances. We chose a selection of big systemic banks and we had a large amount of NPLs. The choice of Greece is then prompted by the significant number of bank failures in recent years. Greece has been affected by the subprime mortgage crisis and the debt crisis.

The data sources for this study include the following sources: Annual Reports of the four (4) Systemic Banks and Bank of Greece (Eurosystem) for the Economic – Banking Ratios and banking information systems that affect credit risk and Reports, the European AMECO Database/ European Commission, World Development Indicators (WDI), Global Financial Development (GFDD) for the macroeconomic factors.

Model

To apply empirically this study, we used both macroeconomic and economic variables. Macroeconomic Data are collected from the AMECO Database/ European Commission, World Development Indicators (WDI), Global Financial Development (GFDD).

For bank specific data, we used the Systemic Banks' annual reports for 10 years (2007 -2017) of the four (4) Systemic Banks. In this study, non-performing loans are explained by four

macroeconomic variables and three bank-specific variables in terms of total capital adequacy and bank's core equity capital against its total risk-weighted assets.

Linear Regression, Least Squares (NLS and ARMA)

$$\text{Equation} \Rightarrow y = c + c(1) + c(2)x_1 + c(3)x_2 \dots$$

Models:

$$1) \frac{NPL}{TL} i, t = \beta_0 + \beta_1 GDP_t + \beta_2 UN_t$$

$$2) \frac{NPL}{TL} i, t = \beta_0 + \beta_1 GDP_{t-1} + \beta_2 UN_t$$

$$3) \frac{NPL}{TL} i, t = \beta_0 + \beta_1 CAR_t + \beta_2 C_t + \beta_3 C_{t-1}$$

$$4) \frac{NPL}{TL} i, t = \beta_0 + \beta_1 CAR_t + \beta_2 TIER1_t + \beta_3 C_t + \beta_4 C_{t-1}$$

Composition

- **NPL / TL i, t:** the ratio of non-performing loans to total loans for the bank in year t.
- **CAR, Capital (tier1) + Capital (tier2) / RWAs i, t:** The ratio is calculated by dividing a bank's capital by its risk-weighted assets.
- **ΔCAR, Capital (tier1) + Capital (tier2) / RWAs i, t-1:** the annual CAR growth over the period t-1.
- **TIER1, Capital (tier1)/ RWA i, t:** the ratio of equity capital and disclosed reserves to its total risk – weighted assets.
- **GDP t:** the percentage of real GDP in the period t.
- **ΔGDP t-1:** annual real GDP growth over the period t-1.
- **C t:** the percentage consumption during period t.

- **ΔC_{t-1}** : annual Consumption growth over the period t-1.
- **UN t**: the unemployment rate in the period t.
- **ΔUN_{t-1}** : annual Unemployment growth over the period t-1.
- **RIR t**: real interest rate in year t.

Multiple regression models in this study:

- c1 = regression coefficient for Macro – Factor of Consumption
- c2 = regression coefficient for Macro – Factor of Unemployment
- c3 = regression coefficient for Macro – Factor of Real Interest Rate
- c4 = regression coefficient for Macro – Factor of GDP
- c5 = regression coefficient for Economic – Factor of CAR
- c6 = regression coefficient for Economic – Factor of TIER1

Estimate Equation (Regression Analysis) is used to examine the influence of independent variables individually toward dependent variable.

- Independent variables are GDP, Consumption, Unemployment, Real Interest Rate, CAR and TIER1.
- Dependent variable is NPL / TL Ratio.

Determinants Factors of NPLs (Non-Performing Loans)

Data analysis method used in this study is multiple linear regressions. Purpose of this analysis method is to identify relationship of independent variables toward dependent variable (NPLs) in order to predict the NPLs' evolution. Hypothesis testing used to understand the influence of independent variables (which will be analyzed below) towards NPLs' prediction.

Data collected from for the period of 2007-2017. The analysis tool for this research is regression using E-views 9 Statistical Software Program.

Statistical Significance

If the study's p-value is $< 0.01^{**}$ then significant**, it would have statistically highly significant result.

If the study's p-value is $< 0.05^*$ then significant*, it would have statistically significant result.

If the study's p-value is > 0.05 then insignificant, it would not be reasonable to use the study as a basis for the NPLs' evolution.

Results

The object of this study is for project NPLs evolution the period of 2007-2017. Sampling technique used for this study is purposive sampling method, the sampling based on certain criteria.

Economic Data are collected from 4 systemic Banks: NBG, Alpha Bank, Piraeus Bank and Eurobank and Macroeconomic Factors from the AMECO Database/ European Commission, World Development Indicators (WDI), Global Financial Development (GFDD).

Table 1: Regression Results for Model 1 for the Systemic Banks

Systemic Bank	GDP Coefficient / P - Value	Unemployment Coefficient / P - Value	R-Squared	Statistical Significance - GDP	Statistical Significance - Unemployment
Alpha Bank	-4.5625 / 0.0019	0.7124 / 0.0365	0.9835	Significant*	Significant*
NBG	-3.1930 / 0.20	1.35 / 0.0491	0.9333	Insignificant	Significant*
Eurobank	-4.2537 / 0.0396	1.0015 / 0.0759	0.9601	Significant*	Insignificant
Piraeus Bank	-9.5910 / 0.0009	-0.9485 / 0.3196	0.9350	Significant**	Insignificant

Quite consistent with theory, the results we have found show a significant and negative relationship between the growth rate of GDP and the NPL (Dash and Kabra 2010; Espinoza and Prasad 2010; Fofack 2005; Jimenez and Saurina 2006; Khemraj and Pasha 2009). Improving the real economy causes a decline in non-performing lending portfolios of Systemic Banks and accordingly, worsening the real economy increases the unsecured loans.

The result of the coefficient GDP indicated that the GDP has negative effect on NPLs evolution. Statistical test showed the p-value of Alpha Bank, Eurobank and Piraeus Bank is < 0.05 . As GDP decreases, the Bank Loan are increasing, especially in Piraeus Bank NPLs Portfolio.

Table 2: Regression Results for Model 2

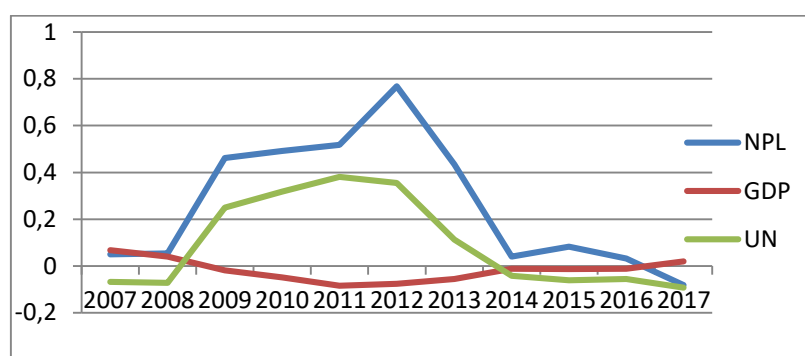
Dependent Variable: NPL
Method: Least Squares
Sample (adjusted): 2007 2017
Included observations: 10 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Statistical Significance
C	-1.682265	0.079984	-21.03254	0.0000	
GDP(-1)	-2.841031	0.748262	-3.796841	0.0067	Significant**
UNEMPLOYMENT	1.326011	0.230965	5.741176	0.0007	Significant**
R-squared	0.971445	Mean dependent var	-1.841441		
Adjusted R-squared	0.963286	S.D. dependent var	0.928333		
S.E. of regression	0.177876	Akaike info criterion	-0.372137		
Sum squared resid	0.221479	Schwarz criterion	-0.281362		
Log likelihood	4.860687	Hannan-Quinn criter.	-0.471718		
F-statistic	119.0705	Durbin-Watson stat	1.487823		
Prob(F-statistic)	0.000004				

The result of the coefficient Unemployment showed the influence of Macro – Factor Unemployment on NPLs is high. Statistical test showed the p-value of Alpha Bank and NBG is < 0.05 . The result of this study reported Unemployment has a positive effect on NPLs evolution. As Unemployment increases, the Bank Loan is harder deprived. Thus, the Non-Performing Loans are increasing.

As far as the unemployment rate is concerned, we found a positive and important relationship with the ratio of non-performing loans to 1%. In fact, unemployed clients cannot fulfill their obligations and return loans that can increase the level of non-performing loans.

In this case, the dynamics of the two variables (GDP growth rate and unemployment rate) is closely linked to households and businesses and the ability to meet their financial obligations. GDP growth usually leads to higher household income and increased profitability. The increase in the unemployment rate limits the current and future purchasing power of households and is generally linked to the decrease in the production of goods and services. Unemployment negatively affects household cash flow and increases debt. As far as businesses are concerned, rising unemployment could lead to a decrease in production due to a decline in real demand. This can lead to a reduction in revenue and a fragile public debt. In this study, the results are similar to those obtained from Louzis et al. (2010) for the case of the Greek banks and Bofondi and Ropele (2011) for the Italian banks.

Figure1: Macro – Variables Evolution in Greece since 2007**Table 3:** Regression Results for Model 3 for the Systemic Banks

Systemic Bank	CAR Coefficient / P - Value	Consumption Coefficient / P - Value	Consumption t-1 Coefficient/ P - Value	R - Squared	Statistical Significance - CAR	Statistical Significance – Consumption	Statistical Significance - Consumption t-1
Alpha Bank	-0.3084 / 0.0155	-9.5642 / 0.0003	3.9568 / 0.0008	0.9951	Significant*	Significant**	Significant**
NBG Greece	-0.6921 / 0.01411	-10.2965 / 0.0003	4.6108 / 0.0202	0.9693	Significant	Significant**	Significant*
Eurobank	-1.4670 / 0.0061	-9.0591 / 0.0005	4.6138 / 0.0014	0.9910	Significant**	Significant**	Significant**
Piraeus Bank	-0.0670 / 0.8201	-9.8906 / 0.0002	3.4288 / 0.0122	0.9893	Insignificant	Significant**	Significant*

The result of the coefficient CAR (Total Capital Adequacy Rate) displayed the influence of CAR (Bank Ratio) has a negative impact on NPLs. Statistical test showed the p-value for all banks is < 0.05 and is statistical significant. The result of this study indicates CAR has a negative impact on NPLs evolution. In fact, the sign of the coefficient is the same as in the international evidence showing that an increase of the CAR will cause a reduction of the NPLs Ratio.

The capital adequacy ratio (CAR) is an international standard that measures a bank's risk of insolvency from excessive losses.

Table 4: Regression Results for Model 4

Dependent Variable: NPL
Method: Least Squares
Sample (adjusted): 2007 2017
Included observations: 10 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Statistical Significance
C	0.136261	0.609642	0.223510	0.8320	
CAR	-1.657026	1.151912	-1.438500	0.209	InSignificant
TIER1	2.410210	0.868595	2.774837	0.0391	Significant*
CONSUMPTION	-7.194752	0.854101	-8.423769	0.0004	Significant**
CONSUMPTION(-1)	2.663911	0.901136	2.956170	0.0317	Significant*
R-squared	0.996475	Mean dependent var		-1.841441	
Adjusted R-squared	0.993656	S.D. dependent var		0.928333	
S.E. of regression	0.073943	Akaike info criterion		-2.064202	
Sum squared resid	0.027338	Schwarz criterion		-1.912910	
Log likelihood	15.32101	Hannan-Quinn criter.		-2.230170	
F-statistic	353.4001	Durbin-Watson stat		2.044454	
Prob(F-statistic)	0.000003				

The result of the coefficient Consumption displayed the influence of Consumption has a negative impact on NPLs in time t, while is positive in time t-1. Statistical test showed the p-value is $0.0004 < 0.01$. It has high statistical importance. Thus, if the Consumption – Macro econometric Factor is rising, non-performing loans are decreasing.

Consumption is the value of goods and services bought by the employed clients. If the clients have purchasing power to raise the consumption, they can fulfil their loans obligations.

In fact, the increase of consumption raises GDP by the same amount.

Consumption is normally the largest GDP component. Moreover, since current income (GDP) is an important determinant of consumption, the increase of income will be followed by a further rise in consumption: a positive feedback loop has been triggered between consumption and income. Thus GDP, Consumption have the same relationship on NPL's evolution.

On the other hand the banking ratio TIER1 has positive relationship with the NPLs portfolio.

Conclusions

In this study, we attempted to create predictive models of NPLs evolution. So identify variables that can affect and affect doubtful accounts in Greek credit institutions from 2007-2017. The results show that GDP growth, Consumption Growth and Capital Adequacy Ratio of credit institutions have a negative impact on non-performing loans. It was found that the banks' capital adequacy ratio, when it grows, is negatively related to NPLs Ratio.

The manifestations of the development of the loan, GDP growth and the evolution of unemployment rates indicate that GDP decline and rising unemployment lead to an increase in NPL. The negative relationship between NPL and GDP growth rates and the positive relationship between NPL and unemployment rate are clearly observable by the 2008 crisis.

These trends confirm the explanations we provide about the relationship between these three variables.

Unemployment rate and real interest rate positively affect impaired loans, so as TIER1 ratio. Every one of these three factors leads the NPL Ratio at a high level and deteriorate the performance of the banks.

The results show that banks should be interested in many variables when offering loans in order to reduce the level of non-performing loans. Banks should also take into account the consumption growth and Unemployment rate of the real economy when extending the loans. Impaired loans are expected to be significant during the economic downturn. Systemic banks should also extend the scope of macroeconomic and banking surveillance to include prudential indicators such as GDP, Inflation, RIR and the banking ratios to assess the robustness and stability of the banking system.

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