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Explaining the first effects of Covid-19 on Greek banks' profitability

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Abstract

The present paper studies the profitability dynamics of systemic Greek banks. By deploying an econometric methodology based on multiple linear regression analysis, we empirically investigate the drivers of banks' return on assets between 2008 and 2020. We also shed light on the first effects of Covid-19 on banks. Examining the effects various macroeconomic, regulatory and financial factors, we find that public debt developments, including Greek debt restructuring, and banks' provisions for credit losses had a negative effect on banks profitability. Besides, we testify that banks' capital adequacy and the size of liabilities of financial institutions towards their customers strengthened chances of increased bank profitability. We discuss the implications of our empirical findings in light of macroeconomic, regulatory and financial developments in Greece and the EU.

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Keywords: Systemic Banks, Profitability, Greece, ROA, Debt Crisis, Covid-19, Financial Analysis, Financial Ratios.

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1 Introduction

Having taken a heavy toll on the income, output and employment variables since the 2009 financial crisis, Greece's economy and, in particular, its banking sector featured salient change. Between 2008 and 2020, the banking sector underwent a structural transformation through the channel of EU-wide changes in banking regulation, the investment landscape, ECB quantitative easing monetary policies, as well as Greece-specific factors. This paper mainly focuses on the latter set of factors, those pertaining to Greece. Aiming to simultaneously tackle fiscal and structural problems – under tight financial constraints – economic policy in Greece took place in an environment of low trust to public institutions, moral hazard and a fragile business environment. This series of drastic economic developments could have not left unaffected the performance of Greek banks.

Between the Lehman Brothers collapse and the outbreak of the pandemic, Greek systemic banks were asked to continue their operation in an even more competitive – yet volatile – EU banking market. Technological advances, new forms of finance, different forms of regulation and cross-border contagion channels shaped the morphology of the Greek banking sector. This required banks to be not only open to new opportunities, but also ready to handle any arising challenges that came along. Besides, they had to support the financing of the Greek economy, distinguish profitable opportunities in a fragile macroeconomic situation with asymmetric information and moral hazard, and continue credit provision to their clients. The issue of high non-performing loans featured prominently both in the academic and the policy debate.

Connecting and fueling economic activity across various sectors of the economy, banks ought to be aware of their dependencies, as well as their links to other economic sectors. As the same time, as entities that not only maximise their own profits, but also constitute the input for other sectors to carry out investment, it is equally important that banks have a clear understanding of the driving factors of their financial performance.

International literature has explored the driving factors of bank profitability during the great recession. In Greece, similar studies are carried out either for previous time periods or in a broader frame, comprising various aspects of bank balance sheets. Yet, the study of Greek bank profitability during the 2008-2020 period remains relatively less studies from an economic perspective. This is the gap that the present paper endeavours to fill through an econometric analysis of key factors often cited in the theoretical and international relevant literature. The principal research hypothesis investigated hereby pertains to the relation between Greek banks' profitability and specific banking indicators of banking regulation, credit losses, deposits, as well as macroeconomic variables. To identify the driving forces of bank profitability during the early pandemic period, we test econometrically the importance of each of these financial and macroeconomic indices on the return on assets of Greek systemic banks.

The rest of the paper is structured as follows. The following section review the relevant literature, which captures both the evolution of the Greek banking sector developments in this time frame, as well as the impact of the pandemic on the banking sector. Then, we present our methodological framework, comprising an econometric investigation into the core of bank profitability factors. This is followed by an analysis of the research results. The last section concludes and discusses the implications of our findings.

2 Literature review

Kotios and Roukanas (2013) analysed the Greek financial crisis in light of the functional responsibilities and inadequacies of eurozone governance. Some of the dimensions of the management of the Greek crisis are the weaknesses of the European decision-making mechanism and European leadership, the economic nationalism displayed by some member states, the risks of contagion of the crisis to the Eurozone and the overreactions of markets and credit rating agencies. According to Katsimi and Moutos (2010), the situation that led to the Greek crisis mainly featured bureaucracy, vested interests and relations between private interests and the public sector, which contributed to the mismanagement of public resources, tax evasion and the deterioration of the quality of public services.

High level of public debt in Greece rendered the implementation of austerity measures necessary, while the contagion dynamics of the Greek crisis justify the implementation of similar measures in other European countries (Kutter, 2014). Provopoulos (2014), claims that the causes of the Greek crisis were the large external and fiscal imbalances. The growing deficit was the result of reduced competitiveness and the expansion of the public sector. Unlike what happened in other countries, the initial crisis in Greece led to a banking crisis.

The country made significant progress in addressing the imbalances and the Bank of Greece managed to restructure the banking system. The resulting conditions have improved the outlook for the Greek economy, as assessed by financial markets. The Greek crisis highlighted the failure of the asymmetric institutional framework of EMU, which was due to its exclusive reliance on internal devaluation, economic fragmentation and lack of counter-cyclical policies, and which led to external imbalances. The Greek problem has pushed the Eurozone in the direction of developing strong policies and institutions and avoiding an existential challenge. Yet, it is argued that the EMU is stronger today, but not necessarily adequately equipped to deal with the next major crisis (Pagoulatos, 2020).

3 The Greek banking sector during the crisis

The banking sector in Greece has been severely affected by the crisis. Considering that the NPE ratio peaked in 2016 at 45%, banks became unable to raise capital. This undermined their intermediation role. Due to the uncertainty of the macroeconomic environment and the country's prospects in the euro area, deposits fell by €117 billion, or 49%, between September 2009 and December 2015. During long recessions, it is expected that higher levels of capital adequacy are required as a buffer against unforeseen risks, which in the case of Greek banks was another obstacle to financing the real economy. These factors, combined with high provisions against loans of low creditworthiness, triggered the banks' continuous losses until 2015. Increased business risk and uncertainty about the future financial situation of households limited the demand for credit. In addition, restrictions on capital movements further hampered economic activity (Stournaras, 2018, Katsaboxakis, 2021). Various researchers (Kosmidou, 2008, Athanassoglou et al., 2008; Van Dooren, 2017; Barkas, Kounadeas & Spatharakis, 2022) have examined the macroeconomic factors that affect the profitability of Greek banks. Besides macroeconomic factors, various studies (Kosmidou & Zopounidis, 2008; Schiniotakis, 2012; Menicucci & Paolucci, 2016; Bongini et al., 2019; Katsaboxakis et al., 2022; Alexiou & Voyazas, 2009; Basdekis et al., 2020; Pasiouras & Kosmidou, 2007; Cheng & Mevis, 2019; Vasiliou & Eriotis, 2012; Barkas, Kounadeas & Spatharakis 2022).

4 Covid-19 pandemic impact on the banking sector

Borri and Di Giorgio (2021) studied the contribution of large European banks to the formation of systemic risk over the last twenty years. They found that all banks contributed significantly to systemic risk, with the largest banks and those most exposed to volatility in the commercial and financial markets bearing the greatest responsibility for its formation. The default risks, which some governments may have initially faced due to the emergence of Covid-19 in Europe, significantly increased systemic risk, but the ECB's announcements regarding its securities purchase programmes have restored calm to the European financial system.

More recent research by Addi and Angelini (2022) investigated the interconnectedness among euro area banks, in relation to the instability it causes in the banking system, over the period 2005-2020. According to the findings, the thirty banks studied have a high degree of interconnectedness. It was also shown that the pandemic had a strong impact on the dynamics of financial system instability, i.e. its structure. More specifically, the analysis revealed that the interconnectedness between credit institutions and the instability they cause in the banking system increases in times of crises, reaching a peak during the outbreak of the pandemic. Large banking institutions play a catalytic role in the transmission of instability, but small and medium-sized banks are also an important factor in the transmission.

Schularick, Steffen and Troeger (2020) showed that low capital levels in banks negatively affect the supply of loans. In contrast, a well-capitalized banking sector in Europe is an important factor that can lead to a rapid recovery after the economic downturn caused by the pandemic. As it was estimated that there would be a significant capital shortfall in European financial institutions, the researchers suggested that a precautionary recapitalisation should be carried out at the European level, with the ESM at the centre.

Using a sample of 1,090 banks from 116 countries for quarterly periods in 2019-2020, Elnahass, Quang Trinh and Li (2021) showed that the pandemic outbreak had negative effects on financial performance ratios and financial stability. The results show high consistency across countries such as the U.S. and China, across countries with differences in income levels and origins, and across banks with different characteristics. The effects of Covid-19 were different in alternative banking systems (i.e., conventional, Islamic). Based on their analysis, it appears that in the second quarter of 2020 bank stability showed signs of recovery.

Additionally, Ari, Chen and Ratnovski (2021) studied the dynamics of NPLs during 92 banking crises since 1990, including the crisis created by Covid-19. Among the crises, there is homogeneity in the accumulation of NPLs and heterogeneity in their impairment rate. High levels of NPLs deepen the recessions that follow crises, so containing them is critical. To address the problem after a crisis such as a pandemic, and given the difficulties many countries have in implementing appropriate policies related to NPLs, the design of effective tools to manage them is required.

The performance of banking institutions since the outbreak of the pandemic reminded the challenges of 2008. The massive liquidations affected all banks, which underperformed compared to other sectors, although there were variations from country to country. CDS spreads increased the most for banks that entered the crisis with high credit risk. The stabilisation measures taken in March 2020 favoured institutions with healthy balance sheets and high profitability, while the ratings of less profitable banks were pulled into negative territory. CDS spreads of institutions exposed to higher risks continued their upward trend even during the stabilisation phase. (Aldasoro, Fender, Hardy & Tarashev, 2020)

Bitar and Tarazi (2020) examined the impact on banks and the economy of supervisory regulatory interventions on NPL management and capital buffers. Applying the easing measures to a sample of Globally Systemically Important Banks (G-SIBs), they find that they can play an important role in sustaining economic growth during the pandemic. However, care should be taken to ensure that the easing does not undermine the solvency of financial institutions during the recovery period. As the effects of Covid-19 on the economy may take time to dissipate, credit institutions should maintain capital buffers ready to be used to absorb future losses.

Focusing on the strategies followed to exit complex macroeconomic conditions, Marcu (2021) analysed the differences between the 2008-2009 crisis and the recent pandemic. The banking system has always been at the centre of crises, but the letter is one in which financial institutions are not part of the problem but rather of the solution. This approach highlights the important role of banks in the response to the coronavirus crisis, as the strategies they adopt have an impact on the entire economy. In recent years, the banking system has been in a process of constant adaptation and renewal, with the aim of reducing costs, keeping up with customer expectations and accelerating digitalisation, due to the increased need for innovation and digital strategies, an element to which the emergence of Covid-19 has contributed.

Studying the daily returns of G7 banking indices, Matos et al. (2021) find that, since the outbreak of the pandemic, the contagion of crises in the financial system has intensified. The analysis of the possible combinations (by pairs) of G7 financial indicators showed that the largest crisis contagion problem occurs between the Italian and French banking systems, i.e. the countries that were severely affected by deaths due to Covid-19, while the Japanese and German banking systems, i.e. the countries that were less affected by the first wave of the pandemic, show the smallest interconnectedness.

The first international study on the impact of Covid-19 on banks' systemic risk used a sample of 1,584 banks from 64 countries (Duan et al., 2021). The result showed that systemic risk increased in all countries. The negative impact on systemic stability was most pronounced for banks with high levels of leverage, risk and loan-to-asset ratios and low capital adequacy.

According to Li et al. (2021), financial institutions can reduce revenue volatility if they diversify from the traditional lending activity by trying to derive revenue from non-interest earning sources. They investigated the impact of the health crisis on the relationship between non-interest income and banks' profits and the risks they take on. They found that income from non-interest activities is positively related to the profitability of credit institutions and negatively related to risk. Therefore, the banks that benefited during the pandemic were those that diversified and sought alternative sources of income other than interest-earning loans.

5 Data and Methodology

The present paper uses the multiple linear regression analysis to estimate a model that has the "*ROA*" as the dependent variable Y and includes five independent variables. Of these, three are banking indicators ("*CAR*", "*Δ%Deposits*", "*PCL*"), one is a macroeconomic variable ("*LnDebt*") and one is dummy variable ("*PSI*"). Based on the results of the regression analysis, the statistical significance of the estimated coefficients of the variables and the existence of a linear relationship between the dependent variable and the explanatory variables are tested. Furthermore, the degree of correlation between the variables shall be examined and a test of multicollinearity shall be carried out. Our analysis also includes a brief presentation of basic descriptive statistics.
Table 1 contains a summary description of the dependent and independent variables used in the model.

Table 1: Variables of the linear regression model

Variable		Description
Y	*ROA*	Return on assets ratio
X_1	*CAR*	(Total) capital adequacy ratio
X_2	*Δ%Deposits*	Annual percentage change in deposits
X_3	*PCL*	Provision for credit losses ratio
X_4	*LnDebt*	Natural logarithm of public debt
X_5	*PSI*	Pseudo-variable for the year that banks were affected by the haircut of Greek government bonds

Our main model is formulated as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon$$

or:

$$ROA = \beta_0 + \beta_{CAR} \times CAR + \beta_{\Delta\%\text{Deposits}} \times \Delta\%\text{Deposits} + \beta_{\text{PCL}} \times \text{PCL} + \beta_{\text{LnDebt}} \times \text{LnDebt} + \beta_{\text{PSI}} \times \text{PSI} + \varepsilon$$

Therefore, the estimated regression equation is formulated as follows:

$$\hat{Y} = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5$$

or:

$$\widehat{ROA} = b_0 + b_{CAR} \times CAR + b_{\Delta\%\text{Deposits}} \times \Delta\%\text{Deposits} + b_{\text{PCL}} \times \text{PCL} + b_{\text{LnDebt}} \times \text{LnDebt} + b_{\text{PSI}} \times \text{PSI}$$

where: b_i are the estimated values of β_i coefficients.

The choice of "*CAR"* and "*PCL"* variables is consistent with the literature, in which their effect on bank profitability is significant. Considering that Greek banks went through a period when lack of confidence led to deposit losses, which started to return when economic sentiment reversed, the variable "*Δ%Deposits"* was included in the model. Banks hold a significant proportion of public debt. With the implementation of the debt write-down programme with the participation of the private sector, the initial fiscal crisis in Greece turned into a banking crisis, affecting the profitability of financial institutions. Therefore, through the model, the effect of the variable "*LnDebt*" and the dummy variable "*PSI*" on the profitability of banks' assets is examined.

The variables constituting banking indicators have been calculated based on data extracted from the annual financial reports of the four systemic banks for the years 2008-2020 (see Annex). The data for the macro variable were retrieved from the online database of "countryeconomy.com" website and processed accordingly. The Annex tables summarise the data used to perform the analysis.

6 Data analysis and results

6.1 Descriptive statistics

Table 2 includes basic descriptive statistics that concern the set of values used for the development of the model (excluding the pseudo-variable).

Table 2: Descriptive statistics (13 years x 4 banks)

	Y=ROA	*X_1=CAR*	*X_2=Δ%Deposits*	*X_3=PCL*	*X_4=LnDebt*
Mean	-0.010641008	0.146405449	0.041722639	0.030412886	5.985575745
Standard Error	0.004324671	0.006631442	0.022237904	0.002537022	0.013648981
Median	0.000110037	0.159591192	0.057579557	0.023545686	5.97119296
Standard Deviation	0.031185646	0.04782001	0.160359809	0.018294725	0.098424202
Sample Variance	0.000972545	0.002286753	0.025715268	0.000334697	0.009687324
Coefficient of Variation	2.930704042	0.326627257	3.843472315	0.601545187	0.016443565
Kurtosis	8.287751496	7.055754399	1.748661022	0.599125107	-0.055686127
Skewness	-2.546185043	-2.160497559	0.727922327	1.021442859	0.511811103
Range	0.181462975	0.274556134	0.864677937	0.078392758	0.360289202
Minimum	-0.134579069	-0.056556134	-0.254592942	0.006788736	5.846042743
Maximum	0.046883906	0.218	0.610084994	0.085181494	6.206331945
Count	52	52	52	52	52

The average value of the 52 observations for the total capital adequacy ratio is at a high level (14.64%). Bank deposits increase on average by 4.17% annually, and the provision for credit losses ratio is around 3% during the examined period. However, the mean of the return on assets index is negative (-1.064%), influenced by extreme values included in our sample (minimum -13.46%, maximum 4.69%). A wide range is observed in the case of variable X_2 values (86.47%). The median, as a measure of central tendency unaffected by extreme values, provides us with even higher capital adequacy (15.96%) and annual growth rate of bank deposits (5.76%). The median value of the observations for ROA is nearly zero.

The values of the variable Δ%Deposits exhibit a large standard deviation (16.04%), while this particular measure of dispersion shows lower variability for the remaining factors. However, in relative terms, using the coefficient of variation, it is noted that both X_2 and the dependent variable Y display very large variability (384% and 293% respectively). In general, the CV values in the above table indicate the heterogeneity of the samples, except for the sample of X_4=LnDebt, where CV<10%.

Interpreting the skewness values for the variables ROA (-2.55) and CAR (-2.16), it is evident that both distributions are highly negatively skewed. The skewness of the PCL variable's distribution is positive, marginally high (1.02), while the distributions of variables X_2 and X_4 are moderately skewed, as the skewness coefficient falls between 0.5 and 1. The negative value of the kurtosis coefficient for variable X_4 (-0.056) indicates a platykurtic distribution, whereas the distributions for the remaining factors are leptokurtic.

6.2 The linear regression equation

The sample consists of 52 observations. It can be seen from Table 3 that the estimated regression equation is as follows:

$$\hat{Y} = 0.209778 \times X_1 + 0.049986 \times X_2 - 0.533732 \times X_3 - 0.003843 \times X_4 - 0.054505 \times X_5$$

or

$$\widehat{ROA} = 0.209778 \times CAR + 0.049986 \times \Delta\%Deposits - 0.533732 \times PCL - 0.003843 \times LnDebt - 0.054505 \times PSI$$

Table 3: Regression

Regression Statistics				
Multiple R	0.942527503			
R Square	0.888358093			
Adjusted R Square	0.857580059			
standard error	0.011480568			
Observations	52			
ANOVA				
	df	***SS***	***MS***	***F***
Regression	5	0.049293024	0.009858605	74.79777368
Residual	47	0.006194762	0.000131803	***Significance F***
Total	52	0.055487786		6.16737E-21
	Coefficients	***standard error***	***t-Stat***	***P-value***
intercept*	0	--	--	--
X_1 =CAR$_1$	0.209777704	0.04468533	4.694554231	2.34363E-05
X_2 =Δ%Deposits	0.049986268	0.011384773	4.390624873	6.37425E-05
X_3 =PCL	-0.533731669	0.090078772	-5.92516594	3.49292E-07
X_4 =LnDebt	-0.003842592	0.001288136	-2.983065121	0.004514098
Dummy X_5 =PSI	-0.05450459	0.008863883	-6.14906442	1.6005E-07

***** As the constant term was found not to be statistically significant, it was removed from the model.

6.3 Testing for statistical significance of the regression equation

The coefficient of multiple determination R^2 indicates that 88.8% of the volatility of the asset return ratio is because of the independent variables of the model. All other factors account for 11.2% of the volatility of the asset return ratio. The adjusted coefficient of multiple determination (adjusted R^2) equals 85.8%, i.e,

3.0 percentage points lower than the simple determination factor. It considers the loss of degrees of freedom, which is due to the addition of variables into the model. Considering the R^2 and R_a^2 values, it could be asserted that the ability of a Greek systemic bank to generate profits in a given accounting year between 2008 and 2020 - based on all its available financial resources - depended approximately 87.3% upon:

- the capital adequacy of the bank,
- the annual percentage change of client deposits,
- the provision for credit losses,
- the domestic public sector debt
- the consideration on whether in that specific year a "haircut" of Greek government bonds occurred.

To test for statistical significance of the linear regression equation, we examine the statistical significance of the R^2 coefficient. We thus test whether the coefficient of multiple determination measures, i.e., the percentage of variability of the dependent variable, which comes from the effects of independent variables and which can therefore be explained by the regression equation, is different from zero. Below, the test is performed at the 1% significance level. We formulate the null and the alternative hypotheses as follows:

H_0: The linear regression equation does not explain the changes of the dependent variable at all.

H_1: The linear regression equation explains part of the variability of the dependent variable

From Table 6 we infer:

$$F_{5.47} = 74.798 \; and \; P(F_{5.47} > 74.798) = \; 6.167 \times \; 10^{-21} < 0.01$$

The area or probability of the $F_{5.47}$ distribution for values equal or above 74.798 is less than the significance level (1%). The null hypothesis is rejected, meaning that at least one partial regression coefficient is non-zero. Therefore, the model is generally statistically significant, at a significance level of 1%. Thus, it is confirmed that the regression equation partially explains the variation in the dependent variable. The percentage of "*ROA*" dispersion explained by the explanatory variables of the model is greater than zero.

6.4 Testing for statistical significance of regression coefficients

Based on the results of the regression, we can test for the statistical significance of its parameters. We chose to do so at the significance level $\alpha = 1\%$. We test for the sign of the partial regression coefficients. We thus get:

- **β_0 coefficient**

***** As the constant term was found not to be statistically significant, it was removed from the model.

- **β_1 coefficient**

To test for the statistical significance, we formulate the null and the alternative hypotheses as follows:

H_0: Capital adequacy does not matter on bank ROA ratio.
H_1: Capital adequacy does matter on bank ROA ratio.

As per the results table (Table 6), we note that $P(|t_{47}| > 4.695) = 2.344 \times 10^{-5}$ for the β_1 coefficient, i.e., the two-dimensional probability corresponding to the value $|t_{47}| = 4.695$ is less than the significance level $\alpha = 0.01$ (p-value < 0.01). Thus, the H_0 hypothesis is rejected and the coefficient of the X_1 variable "*Capital adequacy of the bank*" is statistically significant, other than zero. The coefficient of the X_1 variable is 0.209778, implying a positive impact on the return on assets. Increasing the "*CAR*" index by 1% will increase the "*ROA*" by about 0.0021 points or by about 0.21 percentage points, provided that all other variables of the model remain constant. The positive sign of the factor is deemed reasonable, expected and in accordance with the international literature (Pasiouras & Kosmidou, 2007; Kosmidou, 2008; Schiniotakis, 2012; Menicucci & Paolucci, 2016). It is noted that the emergence of the Covid-19 virus increased the systemic risk of banks. Yet, a stronger impact is noted in the case of banks with low capital

adequacy (Duan et al., 2021). On the other hand, a well-capitalized banking sector can quickly lead to recovery after the economic downturn caused by the pandemic (Schularick, Steffen & Troeger, 2020). Based on the coefficient value, it can be concluded that a change of the "*CAR*" index greatly affects the dependent variable.

- **β_2 coefficient**

To test for the statistical significance, we formulate the null and the alternative hypotheses as follows:

H_0: Change in deposits does not impact on bank ROA ratio.
H_1: Change in deposits does impact on bank ROA ratio.

As per the results table (Table 6), we note that $P(|t_{47}| > 4.391) = 6.374 \times 10^{-5}$ for the β_2 coefficient, i.e., the two-dimensional probability corresponding to the value $|t_{47}| = 4.391$ is less than the significance level $\alpha = 0.01$ (p-value < 0.01). Thus, the H_0 hypothesis is rejected and the coefficient of the X_2 variable "*Annual percentage change of client deposits*" is statistically significant, other than zero. The coefficient of the X_2 variable is 0.049986, implying a positive impact on the return on assets. This is deemed to be expected. Increasing the X_2 variable by 1% will increase the "*ROA*" by about 0.0005 points or by about 0.05 percentage points, provided that all other variables of the model remain constant. The value of the coefficient reveals that a change of the X_2 explanatory variable has a relatively small effect on the dependent "*ROA*" variable.

- **β_3 coefficient**

To test for the statistical significance, we formulate the null and the alternative hypotheses as follows:

H_0: Provisions for credit losses does not affect bank ROA ratio.
H_1: Provisions for credit losses does affect bank ROA ratio.

As per the results table (Table 6), we note that $P(|t_{47}| > 5.925) = 3.493 \times 10^{-7}$ for the β_3 coefficient, i.e., the two-dimensional probability corresponding to the value $|t_{47}| = 5.925$ is less than the significance level $\alpha = 0.01$ (p-value < 0.01). Thus, the H_0 hypothesis is rejected and the coefficient of the X_3 variable "*Provision for credit losses ratio*" is statistically significant, other than zero. The coefficient of the X_3 variable is -0.533732, implying a negative impact on the return on assets. In other words, increasing the "*PCL*" ratio by 1% will result in a fall of the "*ROA*" by about 0.00534 points or by about 0.534 percentage points, ceteris paribus. According to the international literature (Menicucci & Paolucci, 2016; Bucevska & Hadzi Misheva, 2017), the positive sign of the factor is deemed reasonable and expected. Indeed, as high levels of NPLs deepen the recession that follows a crisis, such as the recent pandemic crisis, the development of policies and tools to limit NPLs and, by extension, the provisioning for credit risk losses is of major importance (Ari, Chen & Ratnovski, 2021). In our model, the value of the coefficient reveals that a change of the X_3 explanatory variable greatly affects the dependent "*ROA*" variable.

- **β_4 coefficient**

To test for the statistical significance, we formulate the null and the alternative hypotheses as follows:

H_0: Public debt does not matter on bank ROA ratio.
H_1: Public debt does matter on bank ROA ratio.

As per the results table (Table 6), we note that $P(|t_{47}| > 2.983) = 4.514 \times 10^{-3}$ for the β_4 coefficient, i.e., the two-dimensional probability corresponding to the value $|t_{47}| = 2.983$ is less than the significance level $\alpha = 0.01$ (p-value < 0.01), meaning that the H_0 hypothesis is rejected and the coefficient of the X_4 variable "*LnDebt*" is statistically significant, other than zero. The coefficient of the X_4 variable is -0.003843. This is deemed to be reasonable and expected. An increase in the logarithm of the Greek public debt by one unit will result in a fall of the "*ROA*" by about 0.003843 points or by about 0.384 percentage points, ceteris

paribus. A change of "*LnDebt*" greatly affects the dependent variable. Moreover, according to the international literature, banks are significantly exposed to public debt (Kosmidou, Kousenidis & Negakis, 2015). In Greece, the initial debt crisis led to a widespread financial system crisis (Pagoulatos & Quaglia, 2013; Provopoulos, 2014), causing huge losses to banks, which experienced negative return on assets (Van Dooren, 2017). In particular, institutions specializing in retail banking were hit hard by the subsequent economic downturn, affecting their profitability even in the post-crisis period (Cheng & Mevis, 2019).

- **β_5 coefficient**

To test for the statistical significance, we formulate the null and the alternative hypotheses as follows:

H_0: PSI implementation has no impact on bank ROA ratio.
H_1: PSI implementation has impact on bank ROA ratio.

As per the results table (Table 6), we note that $P(|t_{47}| > 6.149) = 1.6 \times 10^{-7}$ for the β_5 coefficient, i.e., the two-dimensional probability corresponding to the value $|t_{47}| = 6.149$ is less than the significance level $\alpha = 0.01$ (p-value < 0.01). Thus, the H_0 hypothesis is rejected and the coefficient of the X_5 variable "*PSI*" is statistically significant, other than zero. The coefficient of the X_5 variable is -0.054505. The possible values for the pseudo-variable are 1 (if we refer to the year 2011) and 0 (for all other years). If it takes the value 0, the independent variable has no effect on the dependent one. Taking the value 1, it will negatively affect the "*ROA*" index and will reduce it by 0.054505 points or by 5.45 percentage points, ceteris paribus. The negative effect in this case is deemed as expected. As the research of Vousinas (2015) has shown, the "haircut" of bonds incurred a negative impact on Greek banks. In our model, the degree of influence of the pseudo-variable on the dependent variable is found to be very high.

6.5 Conclusions on the linear relation

The above analysis confirms the existence of a linear relationship between the dependent variable ("*ROA*") and the explanatory variables of the model, at the 1% significance level.

7 Correlation analysis

The following table examines the correlation between of the model variables (Table 4):

Table 4: Correlation Matrix

	Y=ROA	*X1=CAR*	*X2=Δ%Deposits*	*X3=PCL*	*X4=LnDebt*
Y=ROA	1				
X1=CAR	0.662255225	1			
X2=Δ%Deposits	0.534955955	0.09113731	1		
X3=PCL	-0.42686403	-0.010585337	-0.226386137	1	
X4=LnDebt	-0.437729499	-0.618686236	0.0711426	-0.1105949	1

Examining the data in the table, we observe a strong positive correlation between the dependent variable Y ("*ROA*") and the independent variables X_1 "*Capital adequacy of the bank*" (66.2%) and X_2 "*Annual percentage change of client deposits*" (53.5%). The dependent variable is negatively, less strongly, correlated with the independent variables X_3 "*Provision for credit losses ratio*" (-42.7%) and X_4 "*Logarithm of public debt*" (-43.8%).

Regarding the correlation between the independent variables of the model, it is worth mentioning the high negative value of the coefficient (-61.9%) for the variables "*CAR*" and "*LnDebt*". Although as a result it is considered reasonable, due to the high coefficient, a test of multilinearity is subsequently performed. A weak positive correlation appears to exist between the explanatory variables X_1 and X_2 (9.1%), while the correlation between X_1 and X_3 is almost zero (-1.1%). The negative correlation between the variables "*D%Deposits*" and "*PCL*" is mild (-22.6%). The coefficient for the X_2 variable relative to X_4 (7.1%) indicates a very limited positive correlation between them. The sign could be explained by the fact that a high public debt forces governments to take measures such as tax increases, which leads to a reduction in private consumption and a tendency to save more. Finally, the negative correlation between the variables "*PCL*" and "LnDebt" (-11.1%) is weak.

8 Testing for multicollinearity

To test for multicollinearity using the VIF coefficient, we need to calculate the multiple determination coefficient for each independent variable of the model, in relation to the other interpretive variables. Therefore, the regression analysis is repeated, setting X_1 as dependent variable and examining its linear relationship with the other interpretive variables of the model. The same exercise is performed again, using X_2 and then X_3 and X_4 as dependent variable. The multiplication coefficients R_j^2 The variance coefficients of expansion (VIF) for the four independent variables were calculated and their values are listed in Table below. At first stage, the pseudo-variable X_5 was not included in the analysis. Then, the process was repeated with its addition.

$$* \text{VIF}_\text{j} = \frac{1}{1 - \text{R}_\text{j}^2}$$

Table 5: Variance coefficients of expansion of independent variables

X_j	Without pseudo-variables		With pseudo-variables	
	R_j^2	VIF_j	R_j^2	VIF_j
X_1	0.403721	1.677066	0.489891	1.960367
X_2	0.076069	1.082332	0.332917	1.499064
X_3	0.064287	1.068704	0.082977	1.090485
X_4	0.407364	1.687377	0.593362	2.459189

Examining the section on the left in Table 5 we see that the value of the VIF coefficient is less than 2 for all four variables, which indicates that the multicollinearity is limited. By repeating the procedure after adding the pseudo-variable (right section of Table), the coefficient values increase. It remains at low levels (1.96, 1.5 and 1.09 respectively) for X_1 ("CAR"), X_2 ("*Δ%Deposits*") and X_3 ("*PCL*") and variables, while it is above 2 (2.46) for X_4 ("*LnDebt*") variable. A coefficient above 2 indicates the existence of a small degree of multilinearity, but is far from the value of 5, at which the problem is particularly severe, and correction is definitely required.

9 Conclusion

The recent operating conditions of Greek financial institutions were marked by anomalies, which, as expected, had an impact on their performance. Bank profitability and efficiency were also impacted by the volatile climate. As a result, shedding light on the elements that drove their achievement was deemed critical. The previous part studied econometrically the factors that affected the return on assets of Greek systemic banks between 2008 and 2020 in order to identify and investigate these driving forces.

The data for the ratio calculations came from the annual financial reports of Piraeus Bank, Eurobank, Alpha Bank, and the National Bank. Electronic database data was also used and processed. Then, after collecting 52 observations (4 banks 13 uses), we built a model with the "*ROA*" index as the dependent variable. We employed the overall capital adequacy ratio, the yearly percentage change in customer bank deposits, the provision for credit losses ratio, and the natural logarithm of Greek state debt as independent variables. In addition, a pseudo-variable was included to the model to capture the effect of the "haircut" of Greek government bonds.

The results of the regression analysis showed that the model is generally statistically significant at the 1% significance level. It turned out that 88.8% (based on the coefficient of multiple determination R^2) of the "*ROA*" variability is explained by the regression function, i.e., due to the effect of the interpretive variables examined[4] . The coefficients of the independent variables are also statistically significant, at a significance level of 1%.

The existence of a linear relationship between the dependent and the independent variables was confirmed. Examining the partial regression coefficients and their signs, we summarise the key findings of our econometric analysis as follows:

- The implementation of the Greek public debt restructuring program, with the participation of the private sector, had a negative impact on the "ROA" index. We find that this is, in fact, the factor with the greatest impact on the dependent variable.
- The coefficient of the variable referring to the provision for credit losses reveals that the latter also puts negative pressure on the return on assets of banks.
- The annual percentage change of the liabilities of financial institutions towards their customers had a positive, albeit small, impact on the "ROA".
- The effect of banks' capital adequacy on profitability is found to be positive and significant.
- The macro-variable we used in the model (public debt) had a negative impact on the return on assets ratio.

The regression analysis findings align with the existing international literature (Vousinas, 2015), which primarily emphasizes the negative impact of the crisis and the implementation of the PSI program on Greek banks. Hence, the signs of the partial regression coefficients are as expected. The restructuring of privately held Greek bonds in 2012 had a devastating effect on banks' balance sheets. This effect could be attributed to the direct impact of bonds held by the four systemic banks or indirectly through the overall negative economic consequences of the PSI program, such as reduced bank deposits, decreased economic activity of bank clients, or increased spreads. Identifying the specific transmission channel of this shock warrants further research, extending the current paper's findings.

Consistent with the literature, our findings also confirm the significant influence of the provision for credit losses (Menicucci & Paolucci, 2016; Bucevska & Hadzi Misheva, 2017) and public debt (Pagoulatos & Quaglia, 2013; Provopoulos, 2014; Kosmidou, Kousenidis & Negakis, 2015; Van Dooren, 2017; Cheng & Mevis, 2019) on the "ROA" index. Additionally, our study demonstrates a positive association between asset returns and well-capitalized banks with access to liquidity, which aligns with previous research by Pasiouras & Kosmidou (2007), Kosmidou (2008), Schiniotakis (2012), Menicucci & Paolucci (2016).

We test for correlation between variables and multicollinearity. The correlation matrix revealed a significant negative correlation between the independent variables "*CAR"* and "*LnDebt"* (-61.9%). The multicollinearity test showed low VIF coefficient for every variable of the model, appreciably lower than the prohibitive levels (value 5).

In this paper, we show that the ability of Greek systemic banks to generate profits during the period 2008-2020, using instruments at their possession, was influenced by specific internal financial and macroeconomic factors. It was shaped under the influence of the debt crisis, which soon turned into a financial crisis, through the PSI implementation. Considering and strategically preparing for potential future

[4] The explainability falls at 85.8%, when based on the adjusted coefficient of multiple determination R_a^2.

financial shocks, our research shows that resilience in bank asset returns requires bank management to focus on maintaining high levels of capital adequacy and liquidity and improving loan portfolio in order to reduce credit losses provisions.

In terms of policy implications, the positive association between asset returns and well-capitalized banks with access to liquidity suggests the importance of maintaining strong capitalization and adequate liquidity buffers in the banking sector. Policymakers should consider implementing measures to ensure that banks have sufficient capital reserves and access to liquidity during periods of financial stress. This can help banks absorb shocks more effectively and contribute to their overall stability and resilience.

The significant effect of provisions for credit losses and public debt on the "ROA" index underscores the need for proactive measures in managing credit risk and reducing public debt burdens. Policymakers should focus on implementing robust risk management frameworks and prudential regulations to mitigate credit losses in the banking sector. Additionally, efforts to reduce public debt levels through fiscal discipline and structural reforms can help improve the financial health of banks and support sustainable economic growth. These policy implications aim to enhance the stability, resilience, and profitability of the banking sector, ultimately contributing to the overall economic well-being of the country.

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Annex 1

Table 6 shows the results of the linear regression analysis.

Table 6: Results of linear regression analysis

Regression Statistics								
Multiple R	0.942527503							
R Square	0.888358093							
Adjusted R Square	0.857580059							
standard error	0.011480568							
Observations	52							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	5	0.049293024	0.009858605	74.79777368	6.16737E-21			
Residual	47	0.006194762	0.000131803					
Total	52	0.055487786						
	Coefficients	*standard error*	*t-Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 99%*	*Upper 99%*
intercept*	0	--	--	--	--	--	--	--
X_1 =CAR_1	0.209777704	0.04468533	4.694554231	2.34363E-05	0.119882417	0.299672991	0.089817451	0.329737956
X_2 =Δ%Deposits	0.049986268	0.011384773	4.390624873	6.37425E-05	0.027083059	0.072889477	0.019423212	0.080549325
X_3 =PCL	-0.533731669	0.090078772	-5.92516594	3.49292E-07	-0.71494678	-0.352516558	-0.77555314	-0.291910198
X_4 =LnDebt	-0.003842592	0.001288136	-2.983065121	0.004514098	-0.006433987	-0.001251198	-0.007300664	-0.000384521
Dummy X_5 =PSI	-0.05450459	0.008863883	-6.14906442	1.6005E-07	-0.072336424	-0.036672757	-0.078300179	-0.030709002

* The constant term is not statistically significant.

Annex 2

Model variables

Dependent variable "*ROA*" (Y)

Year	***Piraeus***	***Eurobank***	***Alpha***	***NBG***
2008	0.244%	0.293%	0.553%	0.620%
2009	0.294%	0.003%	0.637%	0.257%
2010	-0.007%	-0.087%	-0.086%	-0.385%
2011	-13.458%	-6.205%	-6.460%	-13.239%
2012	-1.510%	-2.003%	-2.079%	-3.544%
2013	3.369%	-1.532%	4.688%	0.762%
2014	-2.424%	-2.002%	-0.086%	-0.460%
2015	-2.844%	-1.596%	-1.557%	-5.710%
2016	0.013%	0.016%	0.416%	0.012%
2017	0.004%	0.020%	0.076%	0.014%
2018	0.082%	0.065%	0.114%	0.012%
2019	0.044%	0.059%	0.108%	0.010%
2020	-1.110%	0.034%	0.225%	0.005%

Source: Annual financial reports of banks and authors' calculations

Independent variable "*CAR*" (X_1)

Year	***Piraeus***	***Eurobank***	***Alpha***	***NBG***
2008	11.34%	11.12%	9.30%	16.21%
2009	11.75%	12.40%	13.20%	16.40%
2010	11.19%	12.30%	13.50%	18.54%
2011	-5.66%	13.41%	9.40%	-1.14%
2012	11.00%	13.53%	9.10%	12.00%
2013	15.43%	12.92%	16.40%	15.80%
2014	13.94%	17.17%	14.90%	21.80%
2015	18.10%	18.29%	17.10%	21.30%
2016	17.55%	19.16%	17.30%	16.30%
2017	16.28%	18.90%	18.70%	16.90%
2018	14.68%	16.07%	17.80%	16.70%
2019	15.84%	19.41%	18.30%	17.40%
2020	11.27%	15.20%	18.70%	16.80%

Source: Annual financial reports of banks and authors' calculations

Independent variable "*Δ%Deposits*" (X_2)

Customer deposits (in thousands of EUR)

Year	***Piraeus***	***Eurobank***	***Alpha***	***NBG***
2006	14,606	30,363	20,373	44,565
2007	19,030	38,939	23,335	49,260
2008	24,110	44,467	33,816	56,291
2009	25,730	45,807	35,258	58,081
2010	24,052	40,522	31,234	52,471
2011	18,334	26,864	23,749	44,025
2012	31,108	23,366	23,191	40,908
2013	48,498	33,952	37,505	45,290
2014	50,240	31,985	37,817	44,130
2015	36,971	22,802	27,734	36,868
2016	39,765	23,678	29,010	37,326
2017	41,301	25,015	30,255	38,849
2018	44,919	29,135	33,492	42,249
2019	47,572	32,693	35,541	42,761
2020	50,351	34,448	39,535	47,510

Source: Annual financial reports of banks and authors' calculations

The X_2 independent variable refers to the annual percentage change of the average amount of deposits across the four systemic banks. We calculate the values as follows:

$$\Delta\%Deposits = \frac{Average\ current\ use\ deposits - Average\ previous\ use\ deposits}{Average\ previous\ use\ deposits}$$

whereby, the average amount of deposits for each year is derived from the average of liabilities to customers, considering the deposit levels at the beginning and end of the year. Thus, for the period 2008-2020, we obtained the values below for each financial institution:

Year	***Piraeus***	***Eurobank***	***Alpha***	***NBG***
2008	28.25%	20.35%	30.76%	12.50%
2009	15.53%	8.23%	20.86%	8.36%
2010	-0.12%	-4.37%	-3.74%	-3.34%
2011	-14.86%	-21.94%	-17.31%	-12.71%
2012	16.65%	-25.46%	-14.63%	-11.98%
2013	61.01%	14.11%	29.30%	1.49%
2014	24.03%	15.04%	24.10%	3.74%
2015	-11.67%	-16.91%	-12.97%	-9.42%
2016	-12.01%	-15.16%	-13.44%	-8.40%
2017	5.64%	4.76%	4.44%	2.67%
2018	6.36%	11.21%	7.56%	6.46%
2019	7.27%	14.18%	8.29%	4.82%
2020	5.87%	8.59%	8.75%	6.19%

Source: Annual financial reports of banks and authors' calculations

Independent variable "*PCL*" (X_3)

This is a banking institution's provision to loan ratio, which reflects the cost of risk inherent in loans and advances to customers. A high ratio indicates reduced asset quality, in the loan portfolio, and increased risk costs. Having drawn the necessary data from the annual financial statements of the four Greek banks and performing the necessary calculations for the ratio, the following table is formed for the period 2008-2020:

Year	***Piraeus***	***Eurobank***	***Alpha***	***NBG***
2008	0.80%	1.78%	1.28%	0.68%
2009	0.81%	1.95%	1.31%	1.08%
2010	1.11%	2.34%	1.77%	1.74%
2011	5.84%	2.73%	2.33%	4.16%
2012	5.09%	3.90%	3.98%	4.16%
2013	3.97%	4.48%	3.87%	1.48%
2014	6.45%	5.24%	3.01%	4.42%
2015	6.27%	7.36%	6.34%	8.52%
2016	1.96%	2.58%	2.89%	1.90%
2017	4.23%	2.28%	2.06%	2.32%
2018	1.34%	2.01%	3.84%	0.88%
2019	2.36%	1.79%	2.12%	1.34%
2020	2.86%	1.93%	3.03%	4.18%

Source: Annual financial reports of banks and authors' calculations

Independent variable "*LnDebt*" (X_4)

The values below are expressed in billion US dollars and refer to the general government gross dept of Greece, from 2008 to 2020. Government debt, also known as national debt or public debt is the total financial obligations incurred by the government of a nation (countryeconomy.com, 2022).

Year	***Debt***	***Year***	***Debt***
2008	389,431	***2015***	345,863
2009	419,921	***2016***	348,687
2010	438,237	***2017***	358,658
2011	495,879	***2018***	395,306
2012	391,973	***2019***	370,656
2013	425,653	***2020***	389,588
2014	424,627		

Source: countryeconomy.com

Then, for each year, we calculated the natural logarithm of the corresponding value:

Year	***LnDebt***	***Year***	***LnDebt***
2008	5.964687	***2015***	5.846043
2009	6.040067	***2016***	5.854175
2010	6.08276	***2017***	5.882369
2011	6.206332	***2018***	5.97966
2012	5.971193	***2019***	5.915274
2013	6.053624	***2020***	5.96509
2014	6.051211		

Source: countryeconomy.com and authors' calculations

Independent variable "PSI" (X5)

The "PSI" pseudo-variable aims to detect whether the implementation of the PSI program affected the efficiency of bank assets. Although the "haircut" of Greek government bonds took place in March 2012, capital losses are reflected in the financial statements of banks since 2011. Therefore, the pseudo-variable takes the value 1 for this year and the value 0 for the rest.

Annex 3

Descriptive Statistics

	Formula	*Y=ROA*	*X_1=CAR*	*X_2=Δ%Deposits*	*X_3=PCL*	*X_4=LnDebt*
Mean	$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$	-0.010641008	0.146405449	0.041722639	0.030412886	5.985575745
Standard Error	$se = \frac{s}{\sqrt{n}}$	0.004324671	0.006631442	0.022237904	0.002537022	0.013648981
Median	$\frac{x_{n/2} + x_{n/2+1}}{2}$	0.000110037	0.159591192	0.057579557	0.023545686	5.97119296
Standard Deviation	$s = \sqrt{s^2}$	0.031185646	0.04782001	0.160359809	0.018294725	0.098424202
Sample Variance	$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$	0.000972545	0.002286753	0.025715268	0.000334697	0.009687324
Coefficient of Variation	$CV = \frac{s}{\lvert\bar{x}\rvert}$	2.930704042	0.326627257	3.843472315	0.601545187	0.016443565
Kurtosis	$\frac{n(n+1)}{(n-1)(n-2)(n-3)}\sum_{i=1}^{n}\left(\frac{x_i - \bar{x}}{s}\right)^4 - 3\frac{(n-1)^2}{(n-2)(n-3)}$	8.287751496	7.055754399	1.748661022	0.599125107	-0.055686127
Skewness	$\frac{n}{(n-1)(n-2)}\sum_{i}^{n}\left(\frac{x_i - \bar{x}}{s}\right)^3$	-2.546185043	-2.160497559	0.727922327	1.021442859	0.511811103
Range	$x_{max} - x_{min}$	0.181462975	0.274556134	0.864677937	0.078392758	0.360289202
Minimum	x_{min}	-0.134579069	-0.056556134	-0.254592942	0.006788736	5.846042743
Maximum	x_{max}	0.046883906	0.218	0.610084994	0.085181494	6.206331945
Count	n	52	52	52	52	52*