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"The Price-to-Book Value of European Banks: the Role of Z-score and ESG score "

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Introduction.

In the last twenty years the banking industry has undergo several challenges, the Great Financial Crisis, the debt Crisis and the Covid crisis are among them. Both the American and European financial sector faced these challenges and both faced the difficulties that the crisis brought, but the state in which the two financial systems emerged is quite different. This is particularly visible after the Great Financial Crisis: as reported in the "Financial Stability Review" (ECB, 2019) the P/B values of both European and American banks fell below 1: the American ones were able to recover quickly whereas the European banks struggled and they remained below the unity for a longer period of time showing a banking system less resilient than the American counterparty.

This state of weakness of the European banking system is also mentioned by the ex-president of the ECB Mario Draghi in his report on the future of the European competitiveness presented on 9th September 2024. In the report it's highlighted that the European banks are less profitable than the US ones: they have lower fee and commissions, they face higher costs due to lack of scale and regulatory compliance and also they can rely on a lower level of securitization, equal to the 0.3% of GDP in the 2022 compare to the 4% of the US. In addition the document remarks the fragmentation of the European banking market due to the incompleteness of the Banking Union: as stated in the report (p.288): *"…European banks with cross country operations risk facing regulatory ring-fencing at times of turmoil, which would fragment their internal capital markets along national lines…"* and *"Banks have little incentive to engage in cross-border operations if the transfer of resources from healthy to impaired subsidiaries will be prevented in a crisis."*. To give an example of the difference in dimension of the Bank market capitalization between the European and American one the document reports that the largest US bank, JP Morgan, has a market capitalization larger than the largest 10 European banks combined.

In order to better investigate the challenges that the banking sector is facing is fundamental to understand the P/B ratio due to its large use and its ease of calculation. The Price-to-Book ratio (P/B ratio) is defined as the ratio between the Price on the numerator, which indicates the expected future earnings that investors are buying and the Book value in the denominator which is the result of assets minus liabilities, or net assets (Penman, 2013). Several studies were conducted about what influences the P/B ratio of banks: Calomiris and Nissim (2014) examined

the decrease of the Price-to-Book ratio of U.S. banks during and after the Great Financial Crisis. Using balance sheets and income statements they find that the declines in stock values is due to the deterioration of perceptions of intangibles values attached to different categories of banking activity. Bogdanova, Fender and Takáts (2018) applied a valuation model based on earnings and intangibles on an international sample and they concluded that there were not a substantial change in the factors that drive banks valuation. Non-Performing-Loans and expenses control remained crucial for the bank value.

Other studies are more focused on the European area and they concentrated on the role of the European banks regulation: in "What Determines the Price to Book Ratio in the European Banking Sector" (Ercegovac et al., 2020). it's analyzed the effect of the announcement and implementation of prudential regulations of capital requirements. Ferretti et al. (2018) focus their research on the large European banks taking into account return, risk, size, the composition of the bank activity and country specificities.

With respect to the studies mentioned above, this thesis goes through a different route and analyzes the Price-to-Book ratio using the Z-score and the ESG score.

The Z-score is an index that measures the bank risk. It's calculated by dividing the sum of Return-on-Assets (ROA) and Equity-to-Asset ratio by the standard deviation of the ROA and it connects the bank capitalizations with the volatility of its returns, in short it represents the distance of a bank from its insolvency: a greater value of the Z-score indicates a more stable bank.

The literature presents numerous studies in which the Z-score is used to assess the systematic risk of banks: for example Li et al. (2017) investigate the possibilities of finding a better way in the calculation of the Z-score and they develop a variation of it to better measure the systemic risk of New Zeeland and Australian banks. Chiaramonte et al. (2015) test the effectiveness of the Z-score against other instruments on a sample of European banks.

This thesis uses the Z-score, like the studies mentioned above, but in a different way: instead of using it as a dependent variable in order to assess what influences the systematic risk, it exploits the Z-score information power to investigate its effect on the P/B ratio of European banks.

The P/B ratios are also examined using the ESG score or "Environmental, Social and Governance" risk: it does not only take into account the reputation of a bank but also the risks of the environmental transition, governance and legislative regulation and the relation between the shareholders and the stakeholders of a bank. It is precisely in this relation that the debate focuses: Ersoy, Swiecka et al. (2022) analyze among between the stakeholder theory and

overinvestment theory reflects better on the market value of 176 U.S. commercial banks. Carnevale and Mazzucca (2014) focus more on the importance of the role of reputation in the banking sector, analyzing the relationships between European bank stock prices and the Social Responsibility.

As said before, the object of this study is to determine the influence of the Z-score and ESG score on the P/B ratio of the banks of the European banking system. In order to do that, this thesis is going to use the Ordinary Least Squares (OLS) model: the dependent variables will be the P/B ratios of a sample of E.U. commercial banks selected from the countries of the monetary union for their economic and systemic importance. There will be two regressions, on for each independent variable of interest analyzed: for Z-score, the data will be quarterly collected, whereas for the ESG, the data will be annually as this type of score has only annual frequency release. In order to make the study the more precisely possible in the regressions there will be present other controls variable, their detection of frequency will depend on the frequency of the two main independent variables.

The thesis is articulated as followed: Chapter 1 presents an analysis of the European banking sector: the assets quality, the profitability and the evolution of the Price-to-Book ratio. Chapter 2 gives an overview of the literature about the P/B ratio, the Z-score and the ESG score. Chapter 3 describes the variables used in the models and their expected effects, the sample of the European banks and the databases used to retrieve the necessary data. Chapter 4 presents the models used, the outcomes of their coefficients and how they relate to the previous expectations. To conclude, Chapter 5 contains a summary of the conclusions.

1 Chapter 1: Analysis of the European Banking Sector.

In the recent years the European Union and its economy have faced some important difficulties that had and continues to have important effects on the entire economy and on the Banking Sector: the COVID-19 epidemy forced public authorities to adopt several policies in order to contain its spread. The lockdowns had important impacts on the economy of the E.U. states but also in other important countries such as China, where the very strict policy of zero-covid created several problems in the supply chains of numerous industries. Still in China, in 2021, the financial difficulties of Evergrande, one of the biggest Chinese property developer, have caused an important blow to the Chinese economy. In 2022 the invasion of Ukraine by the Russian Federation followed by the economic sanctions of European Union and U.S. created a major rise in the price of oil and gas that had an important impact on the European energy and industrial sector, the most dependent from the Russian energy supply. In 2021 the inflation, a phenomenon long absent from the European area, has started to rise. This was due to a series of causes: the outburst of the demand long suppressed during the pandemic period, the stress on the international supply chains exacerbated by the high logistical and transportation costs and by the already cited zero-covid policy in China, and the high energy prices caused by the Russian invasion of Ukraine.

In the next two paragraphs there are going to be a brief analysis to better contextualize the European banking market, there are going to take into consideration some aspects: Assets quality, profitability and risk.

1.1 Assets quality.

An important indicator to asses the assets quality of a banking system is the amount of Non-performing loans (NPLs) presented in it. A loan is classified as a “non-performing loan” when the borrower is unlikely to pay, or if more than 90 days have passed without the borrower paying the agreed instalments.

In Figure 1, it’s possible to examine the trend of NPLs in EU countries that participate in the Single Supervisory Mechanism (SSM), from Q2 of 2015 to Q2 of 2024. It’s possible to see a clear decreasing trend of NPLs: at the beginning of 2015 NPLs constituted the 7,48% of the total of gross loans, the trend continued to descend constantly, reaching its lowest point in the Q4 of 2022, at 1,79%. After this date, due to the Covid pandemic, there was a slight rise of NPLs, which represented the 1,92% of gross loans in the second quarter of 2024.

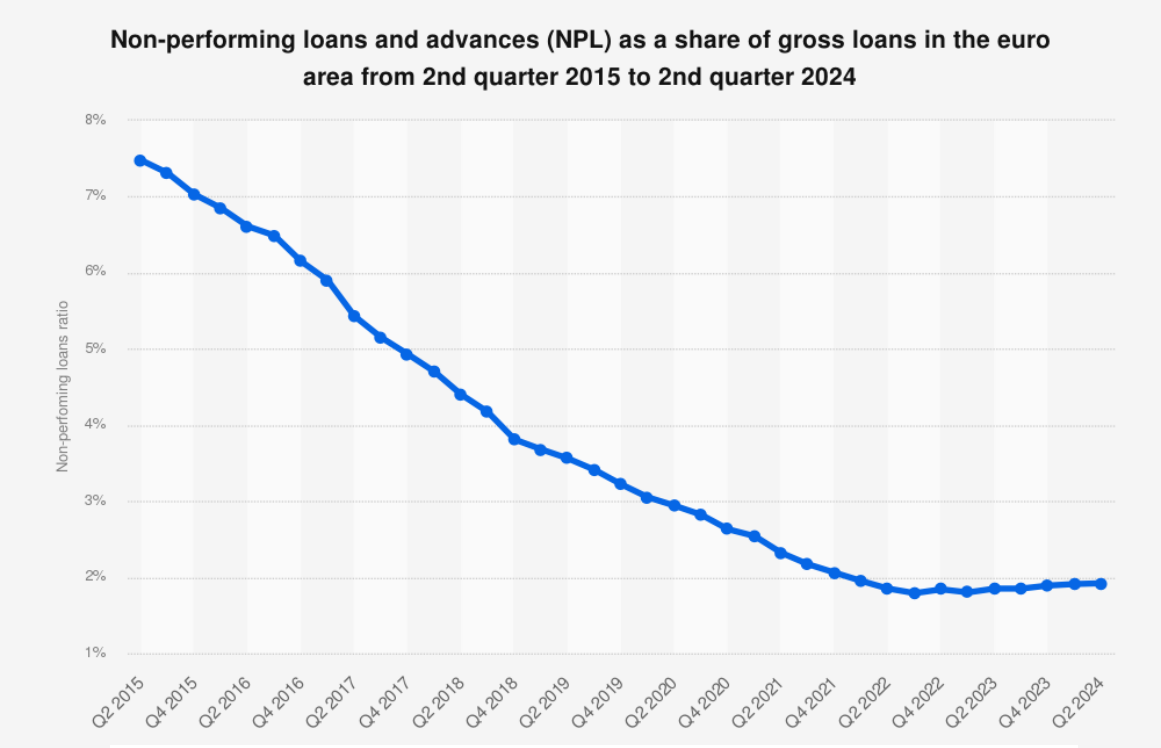

Figure 1. Source: Statista.

This process of improvement of the assets quality can be seen also in more details in the majority of the European banks. In Figure 2 it's represented the percentage of the ratio of NPL over equity in six banks: two Italian, two French and two German. It's possible to see the general downward trend of the ratio after the Debt Crisis in 2010. The two exceptions are the Italian banks, UniCredit and Intesa San Paolo, due to the more fragile condition of the Italian economy and the amount of public debt.

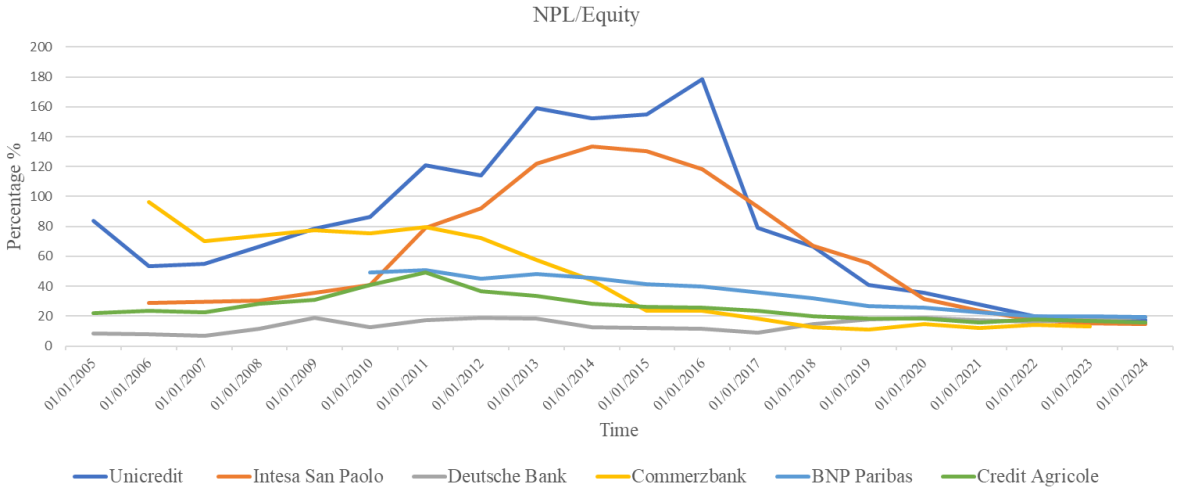

Figure 2. Own elaboration. Data source: Orbis.

Focusing on the last years, despite the market difficulties, the Euro area banks were able to continue their path to improve their assets quality. As noted in the "Financial Stability Review" of May 2022, in the fourth quarter of 2021, the stock of Non-Performing-Loans (NPLs) continue to fall at a 2.1% of total loans and the ratio of loans classified as stage 2 remained stable[1]. This trend continues in the second half of 2022, driven by disposals and securitizations although signs of deteriorations in loans of energy-intensive firms. In March 2023 the failure of Silicon Valley Bank, Signature Bank, First Republic in the U.S. and the rescue of Swiss Bank by UBS in Switzerland created some concerns in the bank market but the impact on the Euro area ones was minimal due to the strong positions in liquidity and capital. Nonetheless NPLs continued their descent but with a lower rate; Stage 2 loans gave some signs of credit deterioration. In the second part of 2023 the tighter financial and credit conditions and their effects on firms and households raised concerns about the banks' assets quality. In contrast with this concerns, the NPLs ratio remained close to its historical lows and the Stage 2 ratio declined[2]. In the end of 2023 and in the beginning of 2024 the NPL ratio remained broadly unchanged but it underwent a recomposition: while it descended for larger enterprises it increased for small firms, an effect attributable to the fact that small firms face more difficulties in a contest of economic aversion. During the 2024, the inflation rate slowed down and the ECB was able to start lowering its policy rates. The Assets quality continues to deteriorate slowly but it remains close to its historical low (Figure 3). The deterioration, although modest, remains concentrated in the Commercial Real Estate (CRE) segment, in the small and medium enterprises (SMEs) segment and in the consumer credit segment. It's important to note that the major drivers of the deterioration of assets quality are CRE and consumer, but the volumes are low and concentrated in a few banks[3].

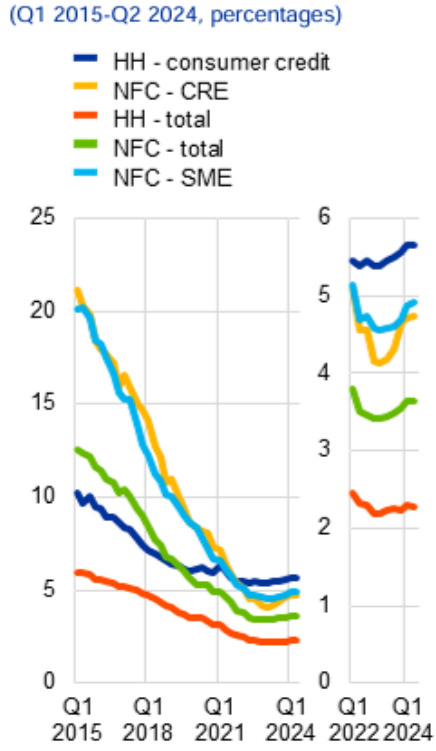

Figure 3. Source: Financial Stability Review, November 2024. ECB.

The graph illustrates the NPLs ratios divided in different categories. From Q1 2015 to Q1 2021 the trend shows a decides downward path. From Q1 2022 throughout 2024, due to the impact on the economy of the Covid-19 pandemic and after due to inflation and the geopolitical situation, the trend has undergone a sharp slowdown.

[1] Page 57-58. Financial Stability Review, May 2022. ECB.
[2] Page 55, Financial Stability Review, November 2023. ECB.
[3] Page 52-53, Financial Stability Review, November 2024. ECB.

1.2 Profitability.

Continuing the overview on the European banking system, an fundamental aspect to take into consideration is the profitability. Starting by looking at the operating income of the European banking industry from 2015 to 2023 in Figure 4. It's possible to see the upward trend of the operating income until the drop of 2020 due to the Covid pandemic. Immediately after the 2020 the operating income gave signal of recovery and in 2023 it registered the result of 759.45 billion, which represents the highest result since 2015.

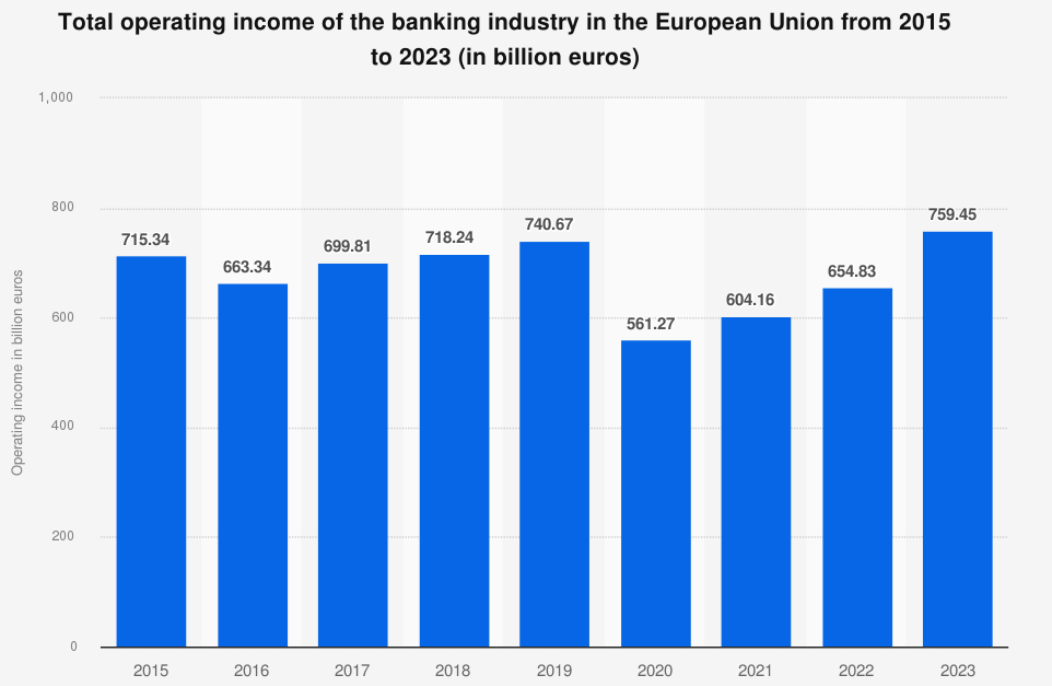

Figure 4. Source: Statista.

In Figure 5 it's possible to observe the profitability taking into consideration the Net Interest Margin (NIM), which is the difference between the Interest Income earns from credit and the Interest Expenses paid to holders of saving accounts and deposits divided by the average earnings assets. It's a measure of profitability of a banking firm. The graph shows a steady downtrend from 2015 to the end of 2021 where it started to slowly increase. In the end of 2022, the beginning of 2023 the NIM increase substantially due to the change of the monetary policy rate: in fact until the rise of inflation after the pandemic, the level of interest rate were kept at a low rate as response of the debt crisis in 2010. This reduced the margin of the banks which started to increase again in the years 2022-2023 when the BCE rose the reference rates.

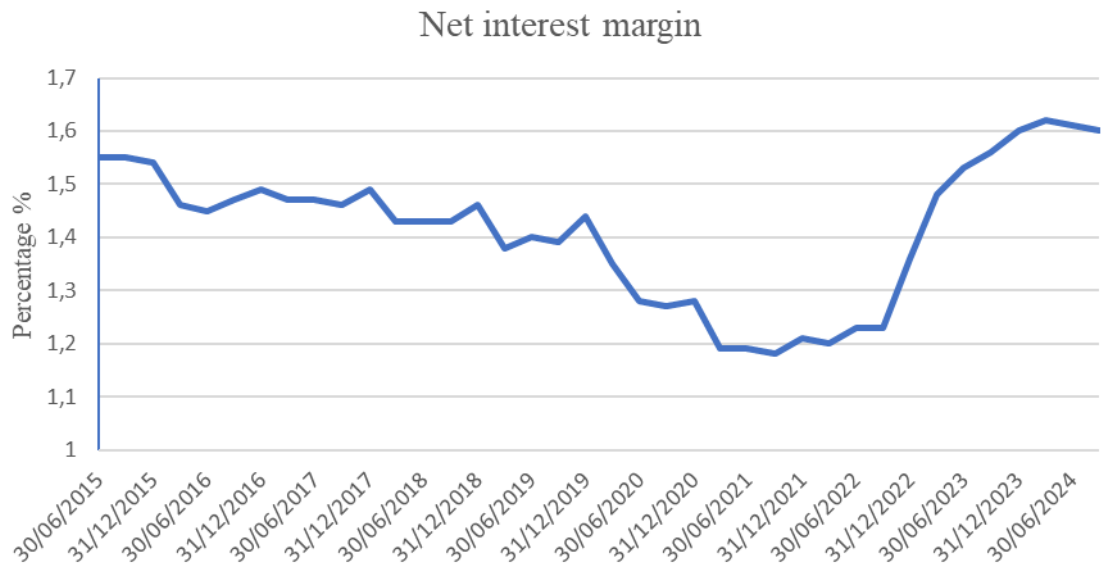

Figure 5. Source: ECB

In Figure 6, it's possible to observe the trend of one indicator of the profitability, the Return-on-Equity (ROE). The graph shows how the Debt Crisis impacted on the profitability of the European banks signing -0,78% and -1,57% in 2011 and 2012 respectively. After that years it's possible to see an upward trend, resulted from the improvements of the economic environment and the results of the monetary policy of the BCE. The impact of the covid epidemic is visible during the years 2019 and 2020, where the ROE, while remaining positive, registered an increase inferior than the previous years. After that event, it continued to improve, reaching 9,29% in 2023, the highest result after 2007. If we exclude the parenthesis of the epidemic, ROE registered a steady increase after the financial and debt crisis, showing the robustness of the European banking market.

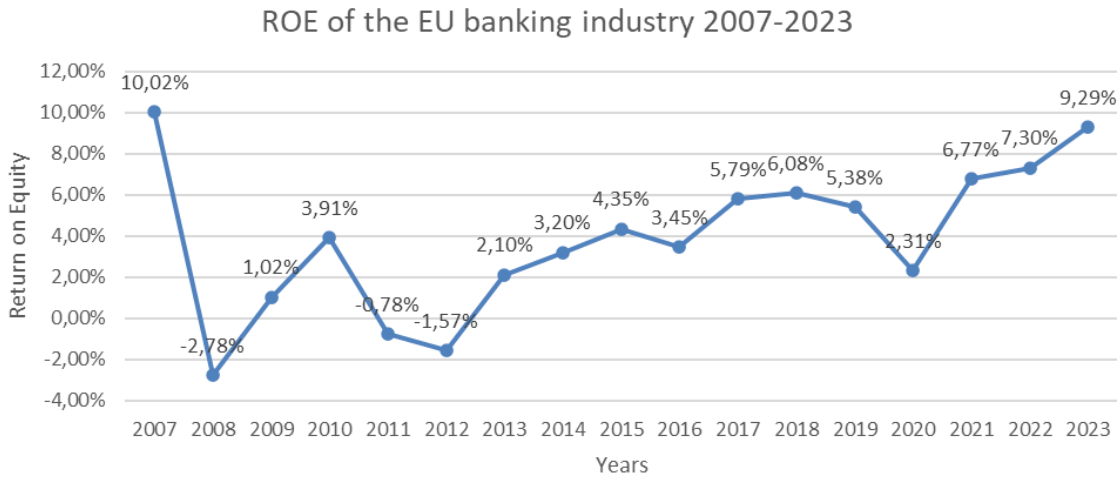

Figure 6. Source: Statista.

The reason of the rise of ROE during the period 2015-2023 while the NIM registered a descending trend, can be found looking at the component of non-interest income of the

European banks. In Table 1 the net fee and commissions of a sample of European banks are collected for the period 2015-2023. With the exceptions of the German banks, the income derived from this part of the activities have increased constantly.

Year	Unicredit	Intesa S.P.	BNP	Deutsche Bank	Credit A.	Commerzbank	Banco Santander
31-12-2015	5.745,2	6.895,0	7.615,0	16.606	2.717,0	3.952,0	12.770
31-12-2016	5.844,7	6.735,0	7.202,0	13.420	2.687,0	3.196,0	12.524
31-12-2017	6.675,9	7.428,0	9.430,0	13.859	3.805,0	3.362,0	13.489
31-12-2018	6.850,0	7.525,0	9.207,0	11.068	4.159,0	3.173,0	13.430
31-12-2019	6.589,0	7.536,0	9.365,0	9.345,0	4.056,0	3.201,0	13.458
31-12-2020	6.168,0	8.005,0	9.579,0	12.221	4.221,0	3.473,0	12.424
31-12-2021	6.703,0	9.398,0	10.362	14.342	5.483,0	3.553,0	12.276
31-12-2022	6.871,0	8.373,0	10.165	12.471	9.039,0	3.130,0	13.601
31-12-2023	6.802,0	7.830,0	9.821,0	15.266	7.298,0	3.493,0	14.701

Table 1. Net Fee and Commission Income, millions EUR. Own elaboration. Data from Eikon.

Focusing on the evolution of the ROE in the last years, at the beginning of 2021 the ROE of Euro area significant institutions was registered at 6.6%, sustained by non-interest income components such as net fee and commission income. The net interest income remained flat[4]. In the second quarter of 2022 the ROE rose to 7% driven partially by higher net interest income due to steeping yield curves. The fee income component of revenues, although remaining an important part, signed a slowdown due to the impact of investors de-risking activities in a climate of higher risk aversion in the financial market. Regarding the costs, especially payroll and administrative, they increase during the year, but at a slower rate than the revenues. In the end of 2022 and beginning of 2023 the interest margins increased the profitability of Euro area banks. This was due to the rise of interest rates and the tardiness in the adjustment of the deposits rate. It's important to note that there is a substantially heterogeneity across individual banks due to structural issues: the problem in the assets quality has been largely addressed with the Single Supervisory Mechanism (SSM) but substantially difference in cost efficiency remained among the weakest banks[5]. In the final quarter of 2023 significant institutions saw a declining of their trailing return on equity, caused by rising operating expenses, lower operating income and higher loan loss provisions. In the second quarter of 2024 banks' ROE reached 9.4% in annual term, the net interest margin peaked indicating its losing momentum as main driver of rising bank profits. The important results in the profitability were mostly driven by a decline in administrative expenses and depreciations. In the "*Financial Stability Review*" of November 2024 regarding the ROE expectations, it's reported that it's unlikely that the ROE will continue to outperform, due to the decline of rates.

[4] Page 63-64. Financial Stability Review, May 2022.
[5] Page 63-64. Financial Stability Review , May 2023.

1.3 Evolution of the Price-to-Book ratio.

Continuing with the description of the evolution of the European banking industry, it's useful to analyze the evolution of the Price-to-Book ratio (P/B) through the last years.

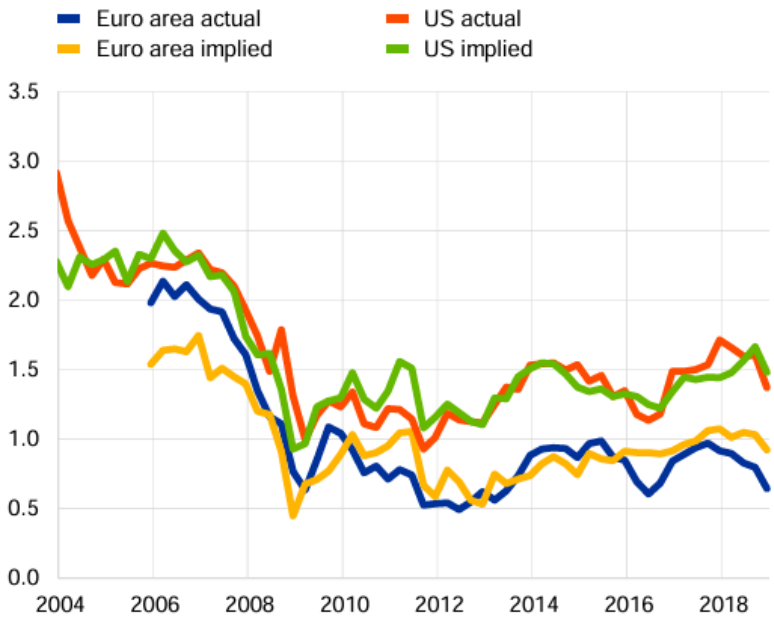

Figure 7A

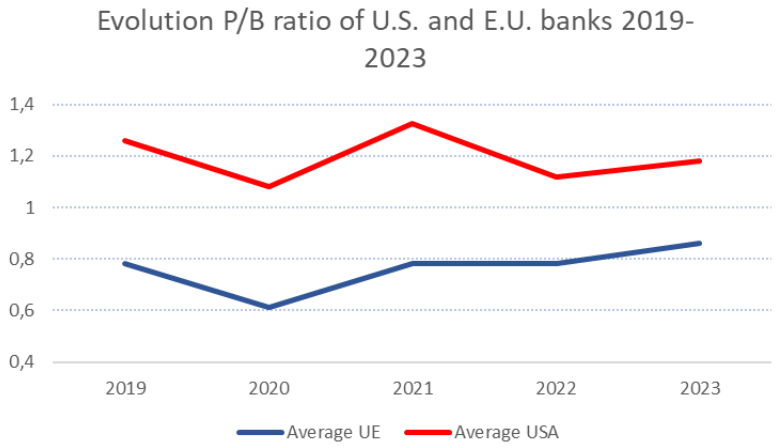

Figure 7B

Figure 7. Actual and model implied P/B ratios in the euro area and US of 70 globally active banks, equally divided into EA and US institutions. "Implied" in 7A is referred to the results obtained by the model used in this in-depth part of the review, not to be considered for the purpose of explanation of P/B. Source 7A: Financial Stability Review, May 2019. Source 7B: Own elaboration. Number of banks considered 51 between US and EU banks.

In Figure 7(A) it's possible to see the evolution of the P/B ratio from 2004 to 2018. In 2007, before the beginning the Financial crisis, the P/B of both European banks and the US banks were above 2, during the year 2009, the ratio dropped at 0,6 for the EU banks while the US ones were able to stay at 1. With the exception of late 2009, beginning 2010, the P/B ratio of

European banks were not able to return pre-crisis level but also they were unable to break the sealing of the unity value of the ratio. It's also possible to notice the impact of the sovereign debt crisis during the period 2010 and 2013, where the P/B ratio reached the level of 0,5. On the contrary, the American banks have registered a constant improvement, reaching the level of 1.6 at the beginning of 2018, showing a better resilience than the European banking market. The comparison between the P/B ratio of European banks and American, Japanese and Scandinavian banks in the last 2 years is visible in Figure 8. The American banks continue to have the highest ratio: they start the 2022 with a ratio equal to 1,5 and after a decline during the 2023 they achieve a ratio of 1,4. The Scandinavian banks maintain a P/B ratio between 1,2 and 1,0 during the years 2022-2024. The European banks, together with the Japanese banks, registered the lowest ratio: at the beginning of 2022 the Eu banks had a P/B ratio of 0,7; it decreased at 0,5 during the year, for then steadily increasing at 0,8 at the end of 2024. What is notable is the increasing in the country dispersion that ranges from a minimum of 0,5 to a maximum of 1,1.

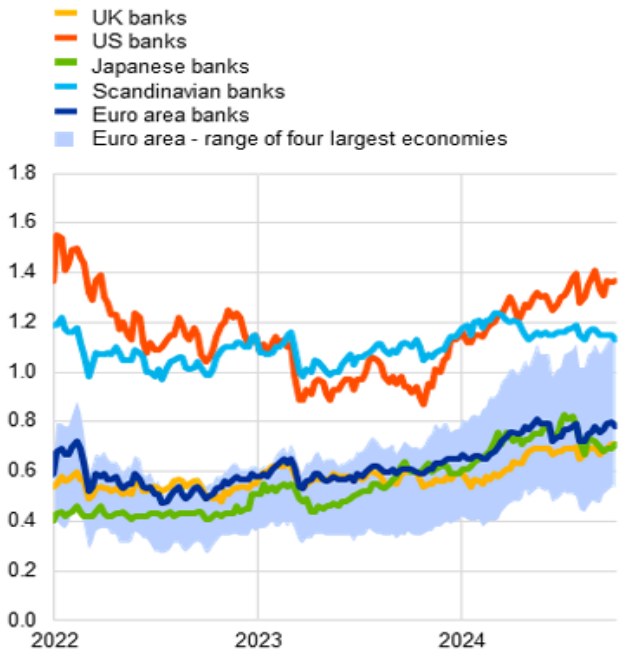

Figure 8. Banks' price-to-book ratio. The four largest euro area economies are Germany, Spain, France and Italy. Source: Financial Stability Review, November 2024.

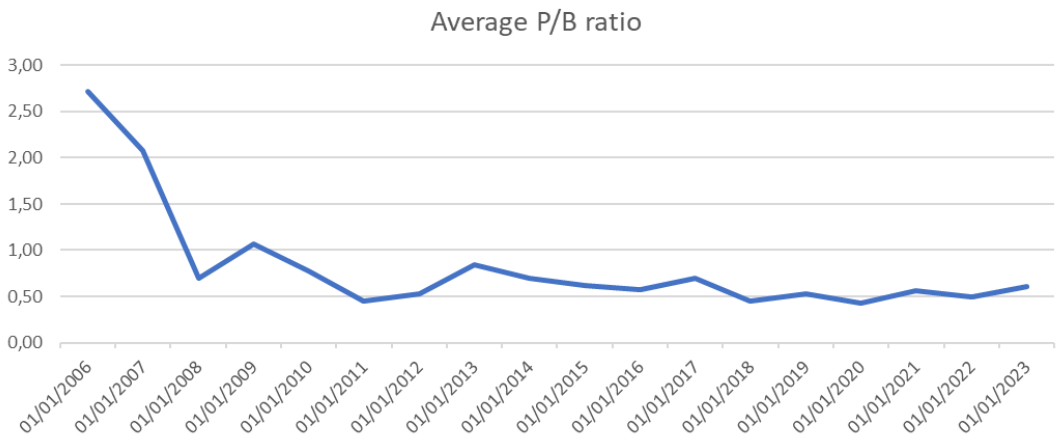

Figure 9. Average P/B ratio of a sample of EU banks. Source: Own elaboration. Data from Eikon.

In Figure 9, the trend of the P/B ratio of a sample of EU banks is clearly descripted: before the Great Financial Crisis the average ratio was about 2,6 with banks such as Commerzbank and Intesa San Paolo that registered a ratio equal to 7,96 and 4,10 respectively, in 2006. After the years 2009-2010 the P/B ratio was unable to rise above the unity value and in the last years it stabilized at the level of 0,6; with the higher banks achieving a level of 0,93 (Banco Bilbao Vizcaya Argentaria SA) and 0,96 (Intesa San Paolo SpA) and the lower at 0,36 (Raiffeisen Bank International AG) and 0,38 (Deutsche Bank AG).

2 Chapter 2: Literature review.

This chapter is dedicated to the collection and display of the literature. The literature is organized into three sections: the first section has as its subject the Price-to-Book ratio, its definition and its literature. The second section focuses on the Z-score and its literature. The third and last section focuses on the ESG score, followed by its literature.

2.1 The Price-to-Book ratio.

In order to better understand the topic of this thesis, it's useful to understand what is the Price-to-Book Ratio (P/B ratio) and why it's a widespread instrument of analysis.

The Book value represents the stockholders' equity in the balance sheet of a firm, it can be obtained by subtracting the value of the liabilities (nonowners' claim) from the value of the assets, as it's shown in this simple equation:

$$Shareholders' equity = Assets - Liabilities$$

But, the book value of equity usually doesn't equal the value that the market attributes and this is due to the expectations on the future earnings that the net assets are likely to generate. This value is expressed by the Market Value which represents the discounted future earnings that an investor is buying. The P/B ratio is the ratio between the Market value of equity and the Book value of equity:

$$P/B\ Ratio = \frac{Market\ Value\ of\ Equity}{Book\ Value\ of\ Equity}$$

In the context of fundamental analysis the Book value of a firm serves as an anchor to the valuation made by the investors and then there is the calculation of the value not captured by the book value, known as the Premium. A measure used to capture this value added is the Residual earnings namely the earnings that exceed a required return on the capital invested.

$$Residual\ Earnings_1 = Earnings_1 - (Required\ Return \times Investment_0)$$

A model where the value is calculated as the present value of residual earnings is called residual earnings model and is calculated as follows:

$$Value = Book\ Value + Present\ Value\ of\ Expected\ Residual\ Earnings$$

2.2 Literature of the P/B ratio in the Banking Sector.

In this section there is a summary of the literature about the P/B ratio in the banking sector. At the beginning they are studies about the U.S. banking market subsequently the focus will be the Euro area banking market.

In the study of 2014, "*Crisis-related shifts in the market valuation of banking activities*" of Charles W. Calomiris and Doron Nissim, it's examined the change of the banks' market to book ratios in the previous decade analyzing the U.S. market. The two authors examine the persistence decline of the P/B ratios and they exclude that it's caused by the delayed recognition of losses on existing financial instruments. They theorize that the decline is explained by several influences:

1. Change in market conditions that do not affect book values but affect intangible loans and deposits relationships.
2. Perceptions of the value of other sources of bank income have changed after the crisis (for example, mortgages servicing fees perceived highly valuable before the crisis and then less valuable).
3. Alteration of the view of the investors about some banks practice after the crisis: investors favored banks with high leverage before the crisis but after it, high leverage is penalized by investors.
4. The change in the term structure of interest rate penalized banks engaged in the "carry trade": borrowing in the form of short-term debts and lending at a fixed rate for longer terms.

In order to verify that, the authors analyzed different accounting measures that they acquired through the FR Y-9C reports on quarterly basis. This is a type of report introduced by the Bank Holding Company Act and it must be submitted by all the Bank Holding Companies (BHCs) with an asset-size threshold of $150 million until 2005, then rose to $500 million. The period under consideration goes from Q1:2000 to Q3:2013. First of all, they verify if the decline in the market-to-book value was caused by unrecognized losses in banks' financial assets. They identify in the loans the primary asset category in which there can be a relevancy of unrecognized losses: this is due to the fact that loans held for investment are reported at the historical cost in the balance sheet and while GAAP enforce the recognition of incurred losses, they disallow to incorporate expected but not incurred losses into provisions for loan losses. Then the authors applied fair value accounting reconstructing the fair value balance sheet for each bank. Comparing the mean of the market-to-book ratio and the mean of the calculated disclosed fair-to-book value, they assumed that if the unrecognized losses play a crucial role in

the decline of the market-to-book value then the decline would be present also in the disclosed fair-to-book value as loss of value of the loans calculated with the fair value. This is not found in the data, as shown in Figure 10, where the mean of fair-to-book value is close to 1 throughout the sample period, whereas the mean of market-to-book value changes substantially; so unrecognized losses on loans and securities explain only a small portion of the large decline. For example between Q4:2006 to Q4:2008 the mean market-to-book value declined from 2.34 to 0.90, whereas the mean fair-to-book ratio declined from 1.01 to 0.97.

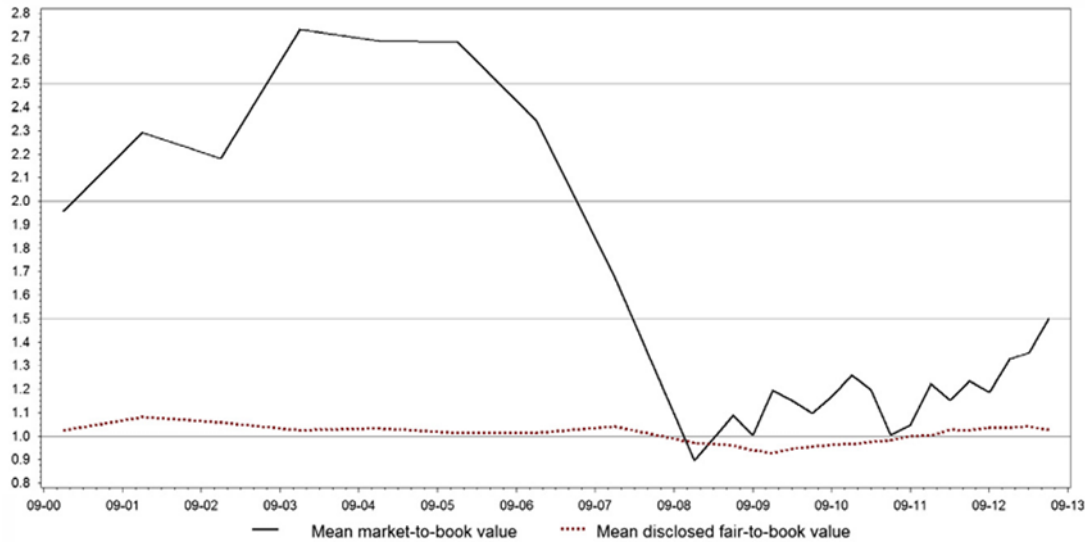

Figure 10. Source: "Crisis-related shifts in the market valuation of banking activities" Pag. 408. Cross sectional means of the reported market-to-book value and fair-to-book value ratios.

Excluded the role of the unrecognized losses on loans and securities, Calomiris and Nissim create a model to explain the market-to-book value, which is the dependent variable. They divide in four groups the valuation drivers of the model:

1. Those that capture values of loans and related relationship intangibles.
2. Those that capture values of core deposits and related relationship intangibles.
3. Those related to the capitalization multiples attached to various type of bank fee income and non-interest expenses.
4. Other characteristics, such as bank asset size, leverage, dividend payments.

The "*Valuation Equation*" resulting:

$$\frac{AdjMarValEq}{TanComEq} = \alpha_0 + \left(\beta_0 + \beta_1 \frac{IntLoans}{AveLoans} + \beta_2 \frac{ALLL}{Loans} + \beta_3 \frac{NPL}{Loans} + \beta_4 \frac{PLLL}{AveLoans} + \beta_5 \frac{NCO}{AveLoans}\right) \times \frac{Loans}{TanComEq}$$
$$+ \left(\gamma_0 + \gamma_1 \frac{NonIntDepo}{CoreDepo} + \gamma_2 \frac{IntCoreDepo}{AveCoreDepo} + \gamma_3 \frac{CoreTimeDepo}{CoreDepo}\right) \times \frac{CoreDepo}{TanComEq}$$
$$+ \alpha_1 \frac{RecNonIntInc}{TanComEq} + \alpha_2 \frac{TranNonIntInc}{TanComEq} + \alpha_3 \frac{NonIntExp}{TanComEq}$$
$$+ \alpha_4 \log(TotAsst) + \alpha_5 \frac{TanComEq}{TotAsst} + \alpha_6 \frac{Dividend}{TanComEq} + \alpha_7 \frac{FixedRateGap}{TanComEq} + \varepsilon$$

Where:

AdjMarValEq = adjusted market value of equity

TanComEq = tangible common equity

IntLoans = trailing-four-quarters (TFQ) tax-equivalent on loans and leases

AveLoans = TFQ daily average balance of gross loans and leases

ALLL = allowance for loan and lease losses

Loans = gross loans and leases

NPL = non performing loans

PLLL = provision for loan and lease losses

NCO = net charge-offs

NonIntDepo = non interest-bearing deposits

CoreDepo = core deposits

IntCoreDepo = TFQ interest on core deposits

AveCoreDepo = TFQ daily average balance of core deposits

CoreTimeDepo = core time deposits

RecNonIntInc = recurring non interest income

TranNonIntInc = transitory non interest income

NonIntExp = non interest expense

TotAsst = total asset

Dividend = common dividends

FixedRateGap = Fixed rate earning assets minus fixed rate liabilities

Loans and leases represent the principal driver of value creation, in the model, this is described by an intercept, the average tax-equivalent yield on loans $\left(\frac{IntLoans}{AveLoans}\right)$ and four measures of credit risk. The ratio of the allowance for loan losses to the gross book value of loans held for investment $\left(\frac{ALLL}{Loans}\right)$, namely the amount of loans held for investment that the bank will be unable to collect; the ratio of non performing loans to the gross book value of loans $\left(\frac{NPL}{Loans}\right)$, which contains information about credit risk; other risk flow proxies included are the ratio of the provision for loan losses to the average balance loans $\left(\frac{PLLL}{AveLoans}\right)$ and the ratio of net charge-offs to the average balance of loans $\left(\frac{NCO}{AveLoans}\right)$. In the liabilities side the following ratios are used to express the value that banks obtain from the deposits with low interest rate and from the spread between market borrowing rates and average interest rate on deposits: the ratio of

non-interest-bearing deposits to core deposits $\left(\frac{NonIntDepo}{CoreDepo}\right)$, the average interest rate on interest-bearing core deposits $\left(\frac{IntCoreDepo}{AveCoreDepo}\right)$ and $\left(\frac{CoreTimeDepo}{CoreDepo}\right)$, which describes the ratio of small-denomination time deposits to core deposits. The impact of non interest income is included using the ratio of recurring fees to tangible book value $\left(\frac{RecNonIntInc}{TanComEq}\right)$ and the ratio of non interest income to tangible book value $\left(\frac{TranNonIntInc}{TanComEq}\right)$. Non interest expenses measure the salaries, employees benefits, expenses of promises and fixed assets and other non interest expenses, all of it is divided by tangible common equity $\left(\frac{NonIntExp}{TanComEq}\right)$. The banking size is taken into consideration using the regressor $(\log(TotAsst))$. To represent the interest rate risk exposure in activities such as the carry trade it's used a proxy $\left(\frac{FixedRateGap}{TanComEq}\right)$ where the fixed rate gape, the difference between fixed-rate earning assets and fixed-rate financial liabilities, is divided by the tangible common equity. To measure the impact of the capital adequacy on the value the ratio of tangible assets to total assets is used $\left(\frac{TanComEq}{TotAsst}\right)$. Lastly a measure of dividends is expressed using the ratio of quarterly cash dividends declared on common stock to tangible common equity $\left(\frac{Dividend}{TanComEq}\right)$.

In the period analyzed the number of observations ranges between 221 to 307 and the number of estimated parameters is 18 per regressions.

The results show that the loan yield was very significant during all the sample period, with the exception during the financial crisis, suggesting that an increase in the risk aversion of the investors in that period, in 2013 the loans yield became significant again. A similar pathway is the one of the four credit related variable: provision, allowance, NPLs and net charge-offs. The NPLs variable remains significant throughout the sample period, whereas the allowance coefficient is relatively insignificant. Net charge-offs is significant during expansions and insignificant during recessions. Regarding the deposits, all the coefficients have the expected signs and are statistically significant. The relationship between the deposit-related fitted value and Treasury rates is not simultaneous, changes in interest rates come before change in the deposit-related fitted value. This can be due to the fact that it takes time to investors to understand the effects on the value of core deposits of change in interest rates and the effects of deposits insurance. Non interest income as said above, is divided into two categories: recurring and transitory non interest income. Before the financial crisis the recurring fees have a bigger impact on the bank value than the transitory ones, but during the period Q3:07 to Q3:08 the two capitalization multiples converge and trend downward. They stay around one until

Q4:12-Q3:13 when they increase significantly. The coefficient of non interest expenses is negative and significant throughout all the sample period but it's magnitude and significance decrease during and after the financial crisis. The ratio of dividend to book ratio remains significant during all the period and its significance increased dramatically during the financial crisis, covering the signaling role of unobserved bank quality. The proxy of interest rate risk, indicating the role of carry trade, although significant throughout the sample period, had a relatively small effect due to the fact that some banks engaged more in this activity while others not. This is testify by the large cross-sectional standard deviation. The coefficient regarding the asset size is positive during all the sample period, especially during the 2001 recession, signaling the benefit of being "too big to fail". Finally, the coefficient of leverage is a positive contributor of market value in regular times, but it assumes a negative value during financial crisis, after it, it becomes insignificant. The shift in contribution of value is due to a change of perception of the investors that, before the crisis, rewarded high leverage banks, but after it they rewarded the low counterparty risk of low leverage banks.

Figure 11 shows the decomposition of the mean of the market-to-book ratio and the contributions of its value drivers.

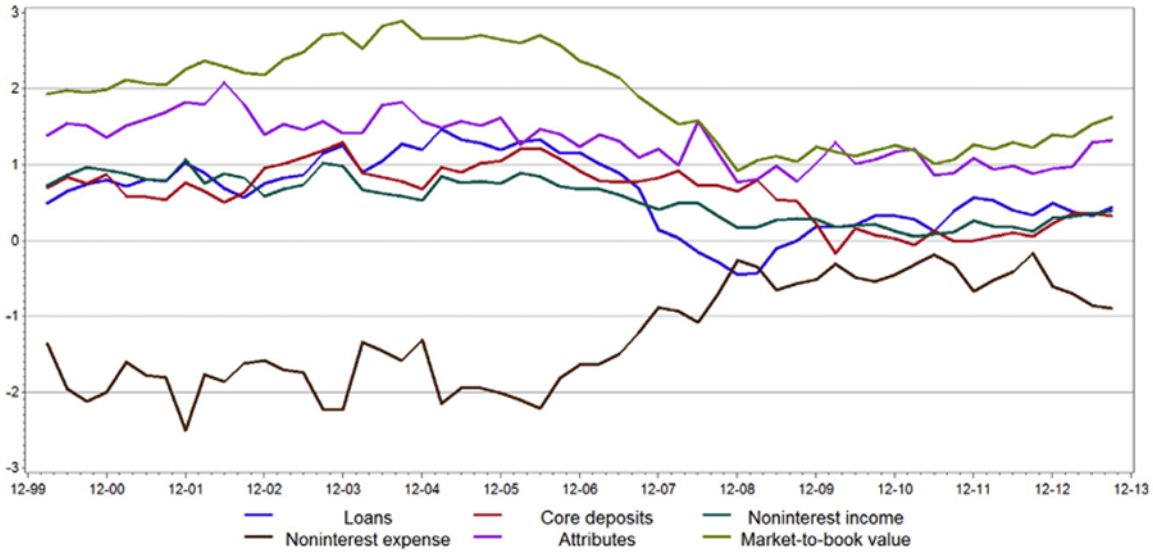

Figure 11. Source: "Crisis-related shifts in the market valuation of banking activities". Pag. 431

In the conclusion the authors write that the model that they developed recognize the intangible assets that banks posses, the heterogeneity of banks non-interest income, the banks' ability of signaling their values through dividends, the financing structure, size and interest rate risk and the variation of values due to changing market conditions. Thanks to this model they were able to track the changes of market price of intangibles assets. The decline in banks stock value since 2007 was driven by the decline of market perception of intangible values of the various banking

activities. Also they highlighted the important signaling power of the dividends and the radical change of view of the leverage, favored before the financial crisis and then seen as penalizing.

Another study that examine the drivers of Price-to-Book ratio is entitled *"The ABCs of bank PBRs"*, it was written by Bilyana Bogdanova, Ingo Fender and Elód Takáts and published in March 2018. Their approach is based on the one of Calomiris and Nissim (2014) described above, with the difference of the addition of the return-on-equity, which served as a proxy for the earnings expectations of the investors and the inclusion in the panel of multi-country banks. Also other accounting indicators of the banking activity are used. The sample is composed by 72 banks from 14 jurisdictions, the data are collected annually for a period between 2000 and 2016. Sources of the date are: Thomson Reuters Worldscope, Fitch Solutions, Bloomberg, Word Bank and IMF.

The model presented is the following:

$$PBR_{ict} = \alpha + \sum_c \beta_c NPL_{ict} + \gamma_1 LOANS_{ict} + \gamma_2 PLL_{ict} + \gamma_3 COREDEPO_{ict} + \gamma_4 NONINTDEPO_{ict} + \gamma_5 NONINTEXPENSE_{ict} + \gamma_6 RNONINTINC_{ict} + \gamma_7 TNONINTINC_{ict} + \gamma_8 ROE_{ict} + \gamma_9 TEQT_{ict} + \gamma_{10} ASSETS_{ict} + \gamma_{11} DIVIDEND_{ict} + \gamma_{12} INTGAP_{ict}$$

There are four sets of explanatory variable which are expressed as ratios to book equity, except for ASSETS and leverage (in logarithms):

1. Loans (*LOANS*), Non-performing loans (*NPL*) and provisions (*PLL*).
2. Core deposits (*COREDEPO*) and non-interest-bearing deposits (*NONINTDEPO*).
3. Variables regarding profits and loss: non-interest expenses (*NONINTEXP*), recurring non-interest income (*RNONINTINC*), transitory non-interest rate income (*TNONINTINC*), and return-on-assets (*ROE*).
4. Other bank metric characteristics: balance sheet leverage (*TEQT*: tangible book equity over tangible total assets), asset size (*ASSETS*), dividend payout (*DIVIDEND*), measure of interest rate risk (*INTGAP*: difference between interest-earnings assets and interest bearing liabilities).

The results shows that the coefficients are mostly statistically significant. NPLs have a negative impact on the bank value, instead provisions have a positive effect, indicating the appreciation of the investors in the bank quality control. Income coefficients contribute to the value whereas non-interest expenses depreciate it. ROE and, once again, dividends show a positive contribution to the bank's value, particularly in the period 2007-2015. The change in the leverage view of the investors pre and post Great Financial Crisis described in the study of

Calomiris and Nissim (2014) is confirmed also in this one: higher capitalization level relative to total assets (lower leverage) is associated with a high price-to-book ratio post financial crisis, implying a change in risk view by the investors.
The study conclude stating that: there doesn't seem to be a change in the factors driving the valuation of banks after the financial crisis; the traditional tools such as proactive management of NPLs and control of non-interest expenses continue to be relevant after the crisis for value preservation and increase and lastly, the results cast some doubts about the assignment of a large role to regulation as a source of low bank valuation.

In order to focus more on the European Banking market, it's taken into consideration the following study, titled "*Market-Book Ratios of European Banks : What Does Explain the Structural Fall?*" written by Riccardo Ferretti, Giovanni Gallo, Andrea Landi and Valeria Venturelli, published in January 2018. The paper starts from the observation of the low growth observed in the European banking market following the Great Financial Crisis, the authors investigate the causes of the phenomenon, focusing the analysis on the large European banks. The sample analyzed consist of 47 banking groups belonging to 13 European countries, with a total asset value greater of 50 billions euro. The period of time taken into account is from 2006 to 2015 and the data are annually collected using SNL Financial database and Thomson Reuters Datastream. The final dataset counts on 411 observations.
The principal measure of profitability is the ROAE (Return on Average Equity), ratio of net income to average equity over the prior year. To measure the risk, it's used the proxy equity volatility (VOL), which consists in the annualized standard deviation of daily stock returns. In addition to these measures, they are used also other measures that aim to capture other bank-specific and country-specific characteristics: the ratio between net interest margin over total operating income (INT) is used to measure the activity diversification of the bank; the credit quality is asses using the ratio of Non-performing-loans over gross loans (NPL); trading assets over total assets (TRAD) is used to measure the engagement in market-related activities; the natural logarithm of total assets (TA) described the bank size. The study also takes into consideration the variables that depend on the country situation: GDP growth, the sovereign debt credit-default-swaps (CDS), the characteristics of the national banking system are described using the concentration index C5 and BRANCH, the ratio between country total banking asset over country total number of bank branches. Lastly, the variable GOVT, calculated as financial instruments in financial institutions subscribed by the government as a fraction of GDP, describes the frequency of state bail out interventions.
The model produced is the following:

$$y_{i,t} = \alpha_{i,t} + \beta_1 ROAE_{i,t} \times VOL_{i,t} + \beta_4 SIZE_{i,t} + \sum_{i=1}^{3} \beta_i BM_{i,t} + \sum_{j=1}^{2} \beta_j MACRO_t + \sum_{r=1}^{2} \beta_r BK_t + \beta_{12} GOVT_t + \varepsilon_{i,t}$$

Where i identifies the banking group (i = 1…47) and t expresses the time variable (t = 2006…2015). Obviously the dependent variable is represented by the M/B ratio.

In the following points there are some clarifications of the equation script:

- *BM* stands for banks' business mix and it groups the following measures: INT, NPL and TRAD.
- *MACRO* explains the macroeconomic country situation and it consist of: GDP and CDS.
- *BK*, national banking system structural characteristics groups the following: C5 and BRANCH.
- *GOVT* variable is the one described above.

The results are in line with the expectation: obviously profitability influences positively the banks market value whereas risk influences it negatively. Size registers a significative and negative value, indicating that larger banks don't have an advantage in value with respect to smaller ones. The variables expressing the banks' business mix sign no statistical significance, contrary on what was registered by Calomiris and Nissim (2014). The macroeconomic variables are all statistical significant: GDP with a positive value and CDS with a negative sign. With regard to the variable expressing the national banking characteristics, only BRANCH is positive and significant, signaling the importance of branch productivity. The variable GOVT is not statistical significant.

In order to explain the relative importance of the variables in explaining the heterogeneity of banks' value among European banks, the authors use the Shapley decomposition method of R2, which allows to distribute the goodness of fit of the econometric model among the regressor variables. The Owen value, a generalization of the Shapley value is used, which allows for decomposition in case of exogenously grouped regressors. The decomposition shows that nearly half of R2 is explained by the variables of the BF group, the other shares have to be linked to time fixed effects in order to capture the shocks happened during the period. In this way BF and YEAR remain relevant but their shares decrease in favor of the group of macroeconomic country variables which count for a 21%. The other variables count for a 5-6%. The Shapley-Owen decomposition is then repeated in four different period of years between 2006 and 2015: 2006-2007, 2008-2010, 2011-2012 and 2013-2015. From these time periods result that the groups of variables in MACRO and BK are the most important in explaining the variance of the M/B ratio in the pre-crisis period, only 19% is explained by bank fundamentals. Their importance grow considerably during and immediately after the financial

crisis, periods 2011-2012 and 2013-15. The BM group has a relevant role in explaining the variance during the crisis, whereas the SIZE, MACRO and BK reduce their importance. In the periods 2011-2012 and 2013-2015 MACRO and BK rise to 20% of variance explanation.
In conclusion, this paper decompose the bank value into different groups to see the contributions of the business fundamentals, size, business composition, banking structure and country macroeconomic effect. It confirms the relevant role of business indicators, the size effect do not support the "too big to fail" hypothesis and the authors justify it with the higher cost this type of banks have to face to fulfil the stringent regulation. Country-specific macroeconomic variables such as GDP and CDS spread are significant and their signs are in line with the expectations, testifying their effects in banks valuation. Another variable significant is the branch productivity, which effect is to attribute a premium by the market valuation to banks with a high branch productivity.

The last paper reported in this literature is "*What Determines the Price to Book Ratio in the European Banking Sector*" (2020) by Ercegovac R., Pečarić M. and Klinac I.. Also in this study there is the observation of the fall of the P/B ratio of the European banks during the financial crisis and their stabilization below the unity after it. The authors research hypothesis remain linked to the idea that the banks' market value is linked to their performance, observable through balance sheets ratios and macroeconomic indicators (Calomiris and Nissim, 2014). What is added in this study is the effect of the regulatory measures entered into force after the crisis.
The analysis is performed in a sample of 23 banking groups with end of year data in the period from 2002 to 2017. The database used are Reuters and Orbis database.
The dependent variable used in the model is the P/B ratio and the independent variables used are the following:

- *IntINC/OpINC*: Interest Income/Operating Income, gives information on the share of interest income in the banking firm's operating income.
- *FeeINC/TA*: Net Fee and Commissions Revenue/Total Assets, indicator of bank's activities not included in the core business.
- *NpA*: Non-performing Assets.
- *GDc/GDPc*: Government Debt/Gross Domestic Product, gives information about the country's government debt relation to its gross domestic products.

In addition to these variables the study analyzes the impact of the regulation change occurred during the time period assuming that any regulatory modelling will cause direct effects on the assets structure and profitability of the banks. To do that in the time period these dates are taken

into consideration: 2010, the announcement of the Basel III Standards; 2013, its implementation; 2015, implementation of the Liquidity Cover Ratio (LCR); 2016/2017, implementation of the Capital Conservation Buffers.

To measure the effects the following variables are used:

- *DLA* – Announcement of regulatory measures. The announcement period of regulatory measures, where the variable is equal to 1, starting from 2010 and lasting until the end of the observed period, and equal to 0 in the others years.
- *DLE* – Enforcement of regulatory measures. Period of enforcement of the regulatory measures, where the variable is equal to 1, starting from 2013 and lasting until the end of the observed period, and equal to 0 in the others years.

Other control variables include the unemployment rate (UNPL) and the inflation rate (CPI) in the EU-28 area.

The model that is produced is the following:

$$\Delta Log\left(P/B_{i,t}\right) = \mu + \gamma \cdot \Delta Log\left(P/B_{i,t-1}\right) + \beta_1 \cdot \Delta LogInt\,INC/OpINC_{i,t} + \beta_2 \cdot \Delta Log\,FeeINC/TA_{i,t} + \beta_3 \cdot \Delta LogNpA_{i,t} + \beta_4 \cdot \Delta\,GDc/GDPc_{i,t} + \beta_5 \cdot \Delta UNPL_{i,t} + \beta_6 CPI_{i,t} + \alpha_i + \varepsilon_{i,t},\ \ i = 1, \dots N, t = 1, \dots T.$$

The results show a significant negative influence on the P/B ratio of interest income to operating income (*IntINC/OpINC)*, a positive impact of fees and non interest income over total assets (*FeeINC/TA*). This suggests that banks with an activity driven more by trade income and non-interest income were viewed more favorably by investors than banks with an activity focused more in a high ratio of interest income. This is in line with Calomiris and Nissim (2014). Like all other studies the independent variable of Non-performing assets (*NpA*) shows a negative effect on the P/B ratio and as shown by Ferretti et al. (2018), the macroeconomic variables play an important role in the variance explanation of the P/B ratios. In this model, the government debt ratio in total GDP (*GDc/GDPc*) indicates a negative effect on the banks' market value.

To study the role of the regulatory announcement variable (*DLA*) and the regulatory measure enforcement variable (*DLE*), two extended models are presented.

Model 2:

$$\Delta Log\left(P/B_{i,t}\right) = \mu + \gamma \cdot \Delta Log\left(P/B_{i,t-1}\right) + \beta_1 \cdot \Delta LogInt\,INC/OpINC_{i,t} + \beta_2 \cdot \Delta Log\,FeeINC/TA_{i,t} + \beta_3 \cdot \Delta LogNpA_{i,t} + \beta_4 \cdot \Delta\,GDc/GDPc_{i,t} + \beta_5 \cdot \Delta DLA_{i,t} + \beta_6 \cdot \Delta UNPL_{i,t} + \beta_7 CPI_{i,t} + \alpha_i + \varepsilon_{i,t},\ \ i = 1, \dots N, t = 1, \dots T.$$

Model 3:

$$\Delta Log\left(P/B_{i,t}\right) = \mu + \gamma \cdot \Delta Log\left(P/B_{i,t-1}\right) + \beta_1 \cdot \Delta LogInt\,INC/OpINC_{i,t} + \beta_2 \cdot \Delta Log\,FeeINC/TA_{i,t} + \beta_3 \cdot \Delta LogNpA_{i,t} + \beta_4 \cdot \Delta\,GDc/GDPc_{i,t} + \beta_5 \cdot \Delta DLE_{i,t} + \beta_6 \cdot \Delta UNPL_{i,t} + \beta_7 CPI_{i,t} + \alpha_i + \varepsilon_{i,t},\ \ i = 1, \dots N, t = 1, \dots T.$$

In the Model 2, the variables are statistical significant as in the previous model, variable *DLA* shows no significant influence. In the Model 3, the variables are statistical significant again with the exception of interest income ratio, whereas the *DLE* variable results significant and positively linked to the P/B ratio.

From all these studies it can be deduced that independent variables derived banks accounting sheets, such as interest income over operating income and total assets are fundamental to study the P/B ratio. Dividends, as cornerstone of the Dividend Discount Model, obviously prove to be another important contributor of the evaluation, not only in the more traditional type of firms but also in the banking industry. Lastly the variable Non Performing Loans is presented and significative in all the studies reviewed and it is essential in order to asses the health of a banking institute. For these reasons, these variables are going to be taken into consideration for the purpose of this thesis and they are part of the model illustrated in following chapters.

2.3 The Z-score.

The Z-score is a measure used to calculate the risk of insolvency of a bank. It's widely used due to the fact of its simplicity of calculation, the low number of data needed and its effectiveness. The following equation shows the Z-score calculation:

$$Z - score = \frac{ROA + (Equity/Asset)}{\sigma_{ROA}}$$

The Z-score is calculated as Return-On-Asset (ROA) plus the Equity-to-Asset ratio (the inverse of the leverage) divided by the standard deviation of the ROA. The effect of this ratio is to link the bank's capitalization, expressed by the equity to asset ratio, with its return, the ROA, and the variability of the ROA, indicated by its standard deviation. In this way, it's possible to calculate the number of standard deviation the bank's asset returns has to drop before the equity of the bank is exhausted and therefore the insolvency is declared. For this reason, the Z-score represents the distance of a bank from insolvency and so, a higher value of Z-score indicates a bank stable and robust.

Various studies[6] identify one of the first use of this instrument in the article: *"Safety First and the Holding of Assets"* by A. D. Roy published in 1952 in the Econometrica journal, where it's

[6] Laeven, Levine (2009); Chiaramente, Croci, Poli (2015); Li, Tripe, Malone (2017).

discussed the problem of the behavior of an individual maximizing his expected gains in condition of uncertainty. This concept was subsequently developed by John H. Boyd and Stanley L. Graham. They published in 1986 a research entitled *"Risk, Regulation, and Bank Holding Company Expansion into Nonbanking"* where it's studied if the diversification into nonbank activities, undertaken by bank holding companies (BHCs) had the effect of decreasing or increasing the bank risk. The research focuses on the period 1971-1983 and it takes into consideration the change of regulation implemented by the Fed in the mid-1970s. The key indicator of risk used is a measure of the probability that the BHC will fail. The risk indicator, labeled Z and defined as: "*...the probability that a BHC will fail, or go bankrupt"* is composed by the profitability measure ROA, its variability (σ) and the ratio between equity and asset.

2.4 Literature of the Z-score.

Although it's grow in popularity there is no consensus on the best way to construct a time-varying Z-score. This issue is the topic presented in "*Bank insolvency risk and time-varying Z-score measures*" of Lepetite and Strobel (2013). The authors observed the absence of a standardized approach in the calculation of the time-varying Z-score and after classified all the approaches presented in other studies into 4 categories and elaborating a fifth one, they evaluate them over a dataset of commercial, cooperative and saving banks belonging to the G20 countries over the period 1992-2009. The approaches differ each other by the calculation of the mean and standard deviation of the ROA and the use of the mean of the capital-asset ratio or the use of the current period *t* values of the capital-asset ratio.

The differences between the approaches can be seen in the construction of the Z-score:

- Approach Z1 uses moving mean estimates of capital-asset ratio ($\mu_{car,t}(n)$), ROA ($\mu_{roa,t}(n)$) and standard deviation of ROA ($\sigma_{roa,t}(n)$) (with window width $n = 3$) that are calculated for each period $t \in \{1 \dots T\}$.
- Approach Z2 uses moving mean and standard deviation estimates($\mu_{roa,t}(n)$, $\sigma_{roa,t}(n)$ with window width $n = 3$), calculated for each period $t \in \{1 \dots T\}$, and combine with current period *t* values of car_t.
- Approach Z3 uses standard deviation estimates σ_{roa}that are calculated over the full sample [1…T], and current period t values of car_t and roa_t.
- Approach Z4 uses "instantaneous" standard deviation estimates $\sigma_{roa,t}^{inst} = |roa_t - \mu_{roa}|$, the mean estimate ($\mu_{roa}$) is calculated over the full sample [1…T], and it's used current period t values of car_t and roa_t.

The fifth approach suggested by the authors is the following:

- The use of the mean and standard deviation estimates μ_{roa} and σ_{roa} calculated over the full sample [1…T] and combine with the current period *t* values of car_t.

After, they investigate which one of the time-varying Z-score measures best fit in the data collected, and to do that they use the root mean squared error (RMSE) criterion. The results show that the car_t, the period *t* value of car, provides the lowest average RMSE for the full sample. Regarding the mean of the return on asset, the mean calculated over the full sample μ_{roa} provides the lowest average RMSE. Lastly, the standard deviation of the ROA calculated over the full sample σ_{roa} produces the lowest average RMSE over the sample. These results support the use of the fifth approach, which it uses the mean and standard deviation of the ROA calculated over the full sample and the use of the current value of the capital-asset ratio.

The issue of the accuracy of the Z-score with respect to other measurements to asses the level of risk, it's the subject of the paper of Chiaramonte et al. (2015), "*Should we trust the Z-score? Evidence from the European Banking Industry*". The authors compare the accuracy of the Z-score with respect to the CAMELS-related covariates in order to assess its ability of signaling through time, bank size, business model and geographical area. The study is conducted on 12 European countries and for the period of time between 2008 to 2012. The sample consists of 3242 banks and 23312 year observation. The data are retrieved from Bureau Van Dijk's BankScope database.

The analysis is conducted using two models: the first one is a probit model where the binary variable equal to one identifies a distress bank at time t in relation to a vector $X_{i,t-1}$ of independent variables of a bank *i* at time $t-1$.

The independent variables are:

- Ln_Z: the natural logarithm of the Z-score, calculated as the sum of ROAA (Return on Average Assets) plus ETA, all divided by σROAA.
- ETA: ratio of equity (book value of common equity) to total assets.
- CRED: ratio of impaired loans to gross loans.
- CIR: ratio of the costs of running the bank to the sum of net interest income and other operating income.
- ROAA: ratio of net income to average total assets.
- LIQ: ratio of net loans to customer deposits and short funding.
- INC_OPREV: ratio of non-interest income to net operating revenue.

The second model used is a complementary log-log model (cloglog), where as, for the fisrt model, the binary variable to identify the bank distress is the dependent variable, the independent variables are the same as for the first model.

To measure the ability of the models to identify the bank in distress, two types of errors are computed: Type 1 and Type 2 error. The former is equal to the ratio false negative events to false negative plus true positive events; the second one is the ratio of false positive to the sum of false positive and true negative events.

Z-score is calculated as:

$$Z - score = \frac{ROAA + ETA}{\sigma ROAA}$$

The results show that the probit and clolog model composed only by the Z-score fail to classify 41 distress events out of 199 and 44 out of 196 respectively. The accuracy is so about 199 out 240 (83%) for probit and 196 out 240 (82%) for cloglog model. Similar results are obtained using CAMELS variables in the two models: probit fails to classify 43 events out of 197 and cloglog 46 out of 194, giving an accuracy of 82% for probit and 81% for cloglog. The authors also regress the Z-score and the CAMELS: the probit model correctly classifies 203 out 240 distress events (84%) while the cloglog correctly classifies 199 out 249 distress events (83%). They also evaluate the effectiveness of the Z-score compared to CAMELS focusing on bank size. The results show no advantages in choosing the CAMELS over Z-score. To conclude, the results show that the Z-score performs as well as the CAMELS variables with the great advantage of needing less data.

The topic of the optimal length and data frequency on which to compute the Z-score is also discussed by Li, Tripe and Malone in "*Measuring bank risk: An exploration of z-score*" (2017). The study is conducted over Australian and New Zealand banks which are considered singularly and jointly for the purpose of systemic risk calculation. The calculation of the Z-scores follows this formula:

$$Z - score = \frac{ROA + (Equity/Asset)}{\sigma(ROA)}$$

Where ROA is computed as net profit after tax divided by average total assets and equity-to-assets ratio is calculated using shareholders' equity not including subordinated debt. Two approaches are used, the first one, Z1, computes moving mean and standard deviation of ROA over previous 16 quarters and it uses the current period value of equity-to-asset ratio. The second one, Z2, uses the range between the maximum and the minimum values of ROA over

previous 16 quarters as volatility measure, the mean of ROA over the previous 16 quarters and current period value of equity-to-asset ratio.

Six New Zealand banks are analyzed for the study, the data are quarterly collected and the period range from 1996 to 2015. Also the Australian banks are composed by a sample of six, but the analysis is limited to annual observations.

The results shows that Z-scores calculated using annual data are greater in value than those obtained on the basis of quarterly data (especially using Z1 approach). This is due to the standard deviation of ROA: the volatility of ROA calculated using 4 annual values is smaller than the one calculated using 16 quarterly numbers. This support the use of quarterly data for a more reliable Z-score estimations. In a context of limitation to annual data, it's advised the use of the range between maximum and minimum of ROA as volatility measure. The optimal window length is identified in 33.9 and 25 quarters, which are approximate 6 years. This is the timeline of a CEO turnover, who can change the bank's strategy and risk exposure. The authors also asses that the selection of the window size depends on the data availability and for that reason they would prefer a 4/5 year window which is the best compromise between observations and change in bank risk profile.

2.5 The ESG score.

The ESG score stands for Environmental, Social and Governance and its purpose is to quantify the degree of which an organization operate in a sustainable manner to be intended not only in an environmental way but in a more broad way. The Environmental part is focused on the sustainability: for example the consumption of water and the greenhouse gas emissions. The Social part is concentrated in the relationship of the firm with the stakeholders that include the workers, the supply chains partners. The Governance part consider how the firm is manage. The ESG score derives from older sustainability scores, such as EHS (Environmental, Health and Safety) and CSR (Corporate Social Responsibility) the difference is the view of ESG score is more focused on business risk and opportunities.

As written in "*ESG risks in banks. Effective strategies to use opportunities and mitigate risks*" of KPMG, in the banks business the sustainability introduces another risk: the ESG risk. In fact the ESG risk can affect the bank directly (natural disaster) but also indirectly affecting customers for example change in the product preference or ethics that can lead to a higher loan defaults. Also it's important to consider the reputational risk that can arise in the relation with

costumers and stakeholders, for example if the bank does business with partners in particular fields.

2.6 Literature of the ESG score.

This part is focus on the literature about the impact of ESG scores in the banking industry. It's taken into consideration the various aspects such as profitability, risk and market valuation.

The relationship between banks' market value and ESG is the topic discussed in *"The Impact of ESG Score on Bank Market Value? Evidence from U.S. Banking Industry"* by Ersoy, Swiecka et al. (2022) where they analyze the impact of the ESG score and its pillars (environmental, social and governance) on 151 American commercial banks over the period 2016-2020, the data are obtained from Eikon database. The models used are the following:

$$(MV)_{it} = \alpha_0 + \alpha_1(MV)_{it-1} + \alpha_2(ESG)_{it-1} + (ESG)^2_{it-1} + \alpha_4(BVLs)_{it-1} + \alpha_5(COVID-19)_t + \varepsilon_{it}$$

$$(MV)_{it} = \alpha_0 + \alpha_1(MV)_{it-1} + \alpha_2(EPS)_{it-1} + (EPS)^2_{it-1} + \alpha_4(BVLs)_{it-1} + \alpha_5(COVID-19)_t + \varepsilon_{it}$$

$$(MV)_{it} = \alpha_0 + \alpha_1(MV)_{it-1} + \alpha_2(SPS)_{it-1} + (SPS)^2_{it-1} + \alpha_4(BVLs)_{it-1} + \alpha_5(COVID-19)_t + \varepsilon_{it}$$

$$(MV)_{it} = \alpha_0 + \alpha_1(MV)_{it-1} + \alpha_2(GPS)_{it-1} + (GPS)^2_{it-1} + \alpha_4(BVLs)_{it-1} + \alpha_5(COVID-19)_t + \varepsilon_{it}$$

Where the dependent variable is the logarithm of the market value (MV) and BVLs are bank control variable (size, beta, capital adequacy ratio, return on assets, income diversity, non-performing loans ratio, risk-weighted assets ratio). The results show a non-linear relationship between ESG score, its subcomponents and the market value: more specifically an inverted U-shaped non-linear relationship between ESG, SPS (Social Pillar Score) variables and market value whereas U-shaped non-linear relationship between EPS (Environmental Pillar Score) and market value. The first relationship implies that the bank market value increases with an increasing investment in ESG but after a threshold the market value starts to decrease. The relationship between SPS and market value follows the same trend as the one between ESG and market value. Whereas the second relationship between EPS and market value has a different impact: at the beginning investments in EPS decreases the market value until a certain threshold where they increase the bank market value. The authors find no statistically significant influence of the GDP (Governance Pillar Score) on market value.

In a study conducted by Di Tommaso and Thorton titled *"Do ESG scores effect bank risk taking and value? Evidence from European banks"* (2020) the effect of the ESG score is study in the

European banking market. The authors analyze the impact of the ESG score in the bank value and in the bank risk profile and determine which of the two views regarding the score would prevail: the "overinvestment view" (or "shareholder view") and the "stakeholder view": the first one assessing that the investment in ESG would deteriorate the profitability and the value diverting scarce resources out of potential investments; the second one assessing that investing in a higher ESG would be positive for the bank value by containing excessive risk-taking by the management. In order to assess this, the authors develop six hypothesis:

Three supporting the stakeholder theory:

1) European banks with higher ESG scores are less risky than those with lower ESG scores.
2) European banks with higher ESG are valued higher than those with weaker lower ESG.
3) The impact of higher ESG scores on bank risk-taking decisions indirectly increases bank value.

Three supporting the overinvestment view:

4) European banks with higher ESG are riskier than those with lower ESG scores.
5) European banks with higher ESG are valued less than those with lower ESG scores.
6) The impact of higher ESG scores on bank risk-taking decisions indirectly reduces bank value.

The study is conducted on 81 banks of 19 European countries over the period 2007 to 2018. The data are from Bureau van Dijk Bank Focus and Asset4-Thomas Reuter.

The hypothesis 1 and 4 are tested on the following model:

$$r_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 X_{it} + D_t + \varepsilon_i$$

where the dependent variable r_{it}measures bank risk (as measure they are used z-score, CDC spread and ratio of non-performing loans over total loans), X_{it} are bank specific variables and $D_t$is a dummy equal to 1 for period 2007Q3 to 2009Q2.

The hypothesis 2 and 5 are tested on the following model:

$$v_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 r_{it} + \beta_3 X_{it} + D_t + \varepsilon_i$$

where v_{it}measures bank value (used Tobin's q and book value of capital).

The hypothesis 3 and 6 are tested on the following model:

$$r_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 ESG_{it} \times r_{it} + \beta_3 X_{it} + D_t + \varepsilon_i$$

to see the ESG scores on bank value conditional on their effect on risk-taking r_{it}.

The results shows that a high ESG score is associated with a reduction in bank risk taking so a statistical significant negative association between ESG and every risk measure used, supporting hypothesis 1 rather than 4 and thus the stakeholder view. However the economic impact is quite small. With regard to the bank value, the ESG score is negative and statistically

significant, supporting hypothesis 5 rather than 2 and also the overinvestment view: an high ESG score subtracts resources from investment opportunities. The last equation verifies if the impact of the ESG score on bank value is conditional on the interaction of the term $ESG_{it} \times r_{it}$. The results shows a positive indirect link between the two terms, however it doesn't compensate for the negative direct impact of the ESG in the investments.

The effect of an high ESG score is also analyzed by Banca d'Italia in "*How important are ESG factors for banks' cost of debt? An empirical investigation*"[7]. The analysis investigates the impact of ESG score in the bank debt market, conducting a research on a sample of 134 European banks of 13 countries over the period 2015-2022. To conduct the research the authors use as dependent variable the spread between plain vanilla fixed-rate bonds issued by euro banks and the yield of German government bonds; the explanatory variables are the ESG scores (three different ESG score ratings are used: MSCI, Refinitiv, Morningstar) and some control variables. The results show a significant and negative relation between ESG scores and spread indicating the relevance for the investors of the information contained. Also it's observed the impact of ESG rating changes on banks' bond yields to maturity: there is a significant medium term effect which consist of an increase in the spread to maturity in case of a downgrade of the score and in a decrease of the spread after an rating upgrade. The two movements are mot symmetrical, the upgrades have a more significant effect than the downgrades.

From the literature it's clear that the ESG score has a significant impact on the bank valuation: the nature of this impact is not unequivocally clear due to the two views that are views that characterize this topic: stakeholders versus shareholder view. What is safe to say is that the ESG score is a relevant and useful source of information that investors have at their disposal.

[7] by Stefano Nobili, Mattia Persico and Rosaria Romeo. October 2024.

3 Chapter 3: Models description, data and variables.

This chapter is dedicated to the description of how the study is structured: the type of statistical models used, the descriptions of the variables presented both dependent and independent, the databases used to recover the data and a description of the composition of the samples of banks used.

3.1 Z-score impact on P/B ratio: model description.

The study is conducted using a panel data analysis, in this way it's possible to follow the sample composed by European banks throughout the period of time taken into consideration, from 2006 to 2024. The regressors used are the following: Pooled OLS estimator, Fixed Effect estimator and Random Effect estimator.

The dependent variable is the Price-to-Book ratio, whereas the independent variable of interest in this study is the Z-score. There are present also other independent variables, which perform the function of control variables.

There are present two models to study the effect of the Z-score: the first one has the same time reference (in this case same year) for the P/B ratio and the Z-score variable, the second model has a one year lag between the P/B ratio and the Z-score: this is done in order to capture possible effects that need time to fully reflect on the market valuation variable. The full models are presented in the Chapter 4, in the following sections are described all the variables in the models and their expected effect.

3.1.1 P/B ratio – Z-score model : variables description.

- $\boldsymbol{P/B_{i,t}}$: it's the dependent variable of the model and it is the ratio between the market value of the bank stock and its book value. They are annual data.
- $\boldsymbol{Z-score_{i,t}}$: the independent variable of interest. It's calculated as shown in Lepetite and Strobel (2013), calculating the mean and the standard deviation of ROAA over the full sample and using the current annual period t of the *Capital-to-Asset ratio*. The difference is in the use of the *Return On Average Asset* instead of the ROA due to data availability. This should not constitute a problem as this ratio is also used in Chiaramonte et al. (2015). Also here all the data use in the calculation are annual findings. It's reasonable to expect that a higher Z-score, meaning a higher index of bank stability, corresponds, ceteris paribus, to a higher P/B ratio.

- $\ln Asset_{i,t}$: independent variable that controls for the size of the bank. It represents the natural logarithm of the annual total asset of a bank. The effect of this variable on the P/B ratio registers an evolution: if at the beginning of the 2000s a bank with a significant dimension was considered more profitable and stable, and so more valuable, after the 2008 crisis this view changed: in Calomiris and Nissim (2014) it has a positive effect, its effect declines after the financial crisis. In Bogdanova et al (2018) the effect is limited before the financial crisis and after it, it becomes insignificant. In Ferretti et al. (2018) the effect of size is statistically significant and negative. In Markoulis et al. (2025), size affects negatively the P/B ratio for banks above the threshold of 50 billions in assets. Seeing the effect of the bank dimension in the other study, it's uncertain what could be the effect of this variable: on one hand an increase in dimension can produce a positive effect on the P/B ratio due to economy of scale, such as bigger volume of revenues and capacity of operations in multiple countries; on the other hand, especially after the financial crisis, investors have changed view on large banks seeing them more risky.
- $ROAE_{i,t}$: independent variable, expressed in percentage, that controls for the profitability of the bank. The use of the ROAE (Return on Average Equity) instead of the more common ROE (Return on Equity) is due to data availability. It's a profitability index resulting from the ratio between the net income and the shareholders' equity. Due to the fact that the Z-score is the result of a ratio that involved the ROA (Return on Asset) and its standard deviation (in this study it's used the ROAA), the use of the ROAA as a control variable for the profitability could reduce the significance of the Z-score in the regression and also could create the risk of correlation between the two variables. The expectations is that the ROAE has a positive effect on the P/B ratio of the European banks: this is shown in Bogdanova et al. (2018) where the ROE index is used and it has a positive effect on the P/B ratio.
- $NPLs_{i,t}$: independent variable, expressed in percentage, that controls for the quality of the bank assets. It's obtained from the ratio of Non-performing loans over gross loans. With "Non-performing loans" they are referred to "exposures which are more than 90 days past-due" and/or "the debtor is assessed as unlikely to pay its credit obligations in full without realization of collateral, regardless of the existence of any past-due amount or of the number of days past due"[8]. This index is used as a proxy of bank's credit quality. In the other studies (Calomiris et al. (2014), Bogdanova et al. (2018), Ercegovac

[8] Page 49, *Guidance to banks on non-performing loans − NPL recognition. (2017).*

et al. (2020)) the variable effects negatively the P/B ratio. Also in this model it's expected to deliver a similar result, affecting negatively the Price to Book ratio.

- $\boldsymbol{LnDeposits_{i,t}}$: independent variable reported as the natural logarithm of the amount of deposit a bank is holding in a given year. The variable includes both the deposits for customers and the deposits due to banks and financial institutions. It's obtained from the annual bank balance sheet. The collection of deposits represents one of the primary activity of a bank and banks generate value by obtaining and maintaining deposits that carry low or zero interest rate. Also the spread generated between the interest rate on deposits and on loans constitutes the Interest Margin, one of the most important voice in the profitability of a bank. Non-interest bearing deposits contribute positively to the P/B ratio, whereas Interest-bearing deposits are shown to effect negatively the P/B ratio (Calomiris et al. (2014)). In our study there isn't a distinction between non-interest and interest deposits, but it's used the total value of deposit due to data availability. Although the absence of distinction between the deposits, the variable is expected to contribute positively to the P/B ratio.
- $\boldsymbol{CART1_{i,t}}$: Capital Adequacy Ratio Tier 1, independent variable that controls for the solidity of a bank. The Capital Adequacy Ratio is an indicator that is obtained dividing the bank's equity by its risk-weighted assets, giving an indicator of the risk of failure and on the capacity of the bank to absorb a reasonable amount of losses before the insolvency. The CAR is divided into two tiers, where the first one, considered here, is composed by core capital, ordinary share capital and reserves. As an indicator of bank solidity and solvency, it's obvious to expect that a bank with a high CAR corresponds, everything else equal, a higher P/B ratio.
- $\boldsymbol{GDP_{i,t}}$: independent variable that express the annual percentage variation of Gross Domestic Product of the country where the bank has its headquarter. It's expressed on constant 2015 prices. A positive and significative GDP growth rate has a positive impact not only on the investment opportunities of a country but also on the public finance and debt bonds market of that country. All of these aspects play have a significative influence on the determination of the value of a bank and, consequently on its Price to Book value. As seen in Ferretti et al. (2018) and Markoulis et al. (2025) the GDP variable has a positive impact on the P/B ratio, it's expected a similar result in this study.

In the following tables all the variables and their predicted effect are summarized:

Dependent Variable	Description
$P/B_{i,t}$	$\frac{Market\ Price\ of\ Equity}{Book\ Value\ of\ Equity}$

Independent Variable	Description	Expected Effect
$Z-score_{i,t}$	$\frac{ROAA+\frac{Equity}{Asset}}{\sigma_{ROAA}}$	+
$\ln Asset_{i,t}$	Natural Logarithm of Asset	+/-
$ROAE_{i,t}$	$\frac{Net\ Income}{Average\ Shareholder\ Equity}$	+
$NPL_{i,t}$	$\frac{Non\ Performing\ Loans}{Gross\ Loans}$	-
$LnDeposits_{i,t}$	Natural Logarithm of Deposits	+
$CART1_{i,t}$	$\frac{Tier\ 1\ Capital}{Risk\ Wheighted\ Assets}$	+
$GDP_{i,t}$	Annual Gross Domestic Product growth at constant price	+

Table 2. Source: Own elaboration.

3.2 The ESG score impact on P/B ratio: model description.

The second part of this study analyzes the effect of the ESG Score on the Price-to-Book ratio. For the purpose of this analysis two models are used: in the first the role of dependent variable is covered by the P/B ratio, whereas the independent variable of interest is the ESG Score; in the second model the dependent variable is the same, whereas the independent variables of interest are: the Environmental Score, the Social Score and the Governance Score. In this way its possible to measure the effects of the individual components.

For each of these models there also a one year lag version: in fact the ESG scores are realized with annual frequency and there is the possibility that the effect of a score change can be reflected in the price of the bank with a time delayed.

As for the Z-score, the study is conducted using panel data, the sample are European banks and the period of time taken into consideration is 2006 to 2023. The regressors used are the following: Pooled OLS regressor, Fixed Effect regressor and Random Effect regressor. The full models are presented in the Chapter 4, in the following sections are described all the variables in the models and their expected effect.

3.2.1 P/B ratio – ESG score model: variables description.

- $\boldsymbol{P/B_{i,t}}$: it's the dependent variable of the model. It's used the same variable as the model before: the ratio between the market value of the bank and its book value. The data are taken with an annual frequency.
- $\boldsymbol{ESG_{i,t}}$: independent variable that indicates the overall score in the three categories that compose the ESG score: Environmental, Social and Governance. The scores are taken from the Eikon database and therefore they are calculated using LSEG methodology. They have annual frequency. It's reasonable to expect that a higher ESG ratio corresponds a higher market valuation of the bank and a higher value creation for the stakeholders: a high ESG score reduces the bank's cost of debt (Nobili et al. (2024)) and the bank risk (Neitzert, Petras (2021)). Although there are studies that show that the relation between ESG score and bank valuation could be not linear (Ersoy et al. (2022)) or have uncertain effect (Di Tommaso, Thornton (2020).
- $\boldsymbol{Env_{i,t}}$: independent variable representing the score obtained by the bank in the Environmental Pillar of the ESG score. The Environmental Pillar Score (EPS) takes into consideration a variety of aspects: not only the emissions or the carbon footprint of the bank activity itself but also the influence of the business activities and firms with which the bank have financial relationships and the environmental policies of the firms that the bank has in its portfolio. All this aspects have to be considered not only in the risk of the impact of the climate change in the supply chain but also in the risk of the impact of government policy changes due to environmental sensitivity and in the reputational risk of the bank. It's expected a positive impact of this variable on the Price to Book value: in Miralles-Quirós (2019) the Environmental score has a positive impact on the shareholder value creation, in Neitzert and Petras (2022) the variable has a positive influence in the reduction of bank risk, also in Ersoy et al. (2022) the EPS has a positive effect on the bank market value although with a non-linear relationship.
- $\boldsymbol{Soc_{i,t}}$: independent variable representing the score obtained by the bank in the Social Pillar of the ESG score. The Social Pillar Score (SPS) takes into consideration characteristics such as: working conditions, the remuneration and the quality of the working environment. The outcome effect of this variable on the Price-to-Book ratio varies depending on the study: in Nobili et al. (2024) the SPS affects negatively the banking risk, similar results are in Neitzert and Petras (2022); in Miralles-Quirós (2019) it registers no direct effect on the value of a bank whereas in Ersoy et al. (2022) the SPS

score increase the value of the bank up to a certain threshold, suggesting a non-linear relationship. Taking into consideration these results, the expected effect of this variable is uncertain.

- $\boldsymbol{Gov_{i,t}}$: independent variable representing the score obtained by the bank in the Governance Pillar of the ESG score. The Governance Pillar Score (GPS) takes into consideration the management process of the bank: the governance structure, the decision making process and the involvement of the shareholders and stakeholders in the strategy of the bank. It's expected that a bank with a high score in the Governance Pillar is less susceptible to management problem and misbehavior of its employees ensuring higher profitability and a higher market valuation. This is present in Miralles-Quirós (2019) where GPS affects positively the bank value. Regarding the cost of debt, in Nobili et al. (2024) it's shown a positive impact of GPS in the reduction of bank cost of debt and in Neitzert and Petras (2022) a good score in GPS is associated with a reduction of risk. For these reasons it's reasonable to expect an improvement of Price to Book value due to a high GPS score.
- $\boldsymbol{ROAA_{i,t}}$: independent variable, expressed in percentage, that controls for the profitability of the bank. The use of ROAA rather than the most classic ROA is due to data availability. The ROAA index is used in Chiaramonte et al. (2015) where they also obtain similar results using the Return on Average Equity (ROAE)[9]. Being a profitability index, it's expected that the ROAA index will have a positive effect on the Price-to-Book ratio, as reported in the Financial Stability Review of May 2019[10]: in Bogdanova et al. (2018) the ROE index is used and it has a positive effect on the P/B ratio, ROA and ROE are similar index, so the effect on the P/B ratio will be similar.

The other variables presented in the model ($\ln Asset_{i,t}$; $NPLs_{i,t}$; $LnDeposit_{i,t}$; $CART1_{i,t}$; $GDP_{i,t}$) are the same as the Z-score models and they paly the same role for the purpose of the regression. It's expected they have the same effect on the Price to Book ratio.

In the following table all the variables and their predicted effects are summarized:

Dependent Variable	Description
$\boldsymbol{P/B_{i,t}}$	$\frac{Market\ Price\ of\ Equity}{Book\ Value\ of\ Equity}$

[9] Page 118 – *Should we trust the Z-score? Evidence from the European Banking Industry (2015).*
[10] Page 68, *Financial Stability Review, May 2019.*

Independent Variable	Description	Expected Effect
$ESG_{i,t}$	Environmental, Social and Governance Score	+
$Env_{i,t}$	Environmental Pillar Score	+
$Soc_{i,t}$	Social Pillar Score	+/-
$Gov_{i,t}$	Governance Pillar Score	+
$\ln Asset_{i,t}$	Natural Logarithm of Asset	+/-
$ROAA_{i,t}$	$\frac{Net\ Income}{Average\ Total\ Assets}$	+
$NPL_{i,t}$	$\frac{Non\ Performing\ Loans}{Gross\ Loans}$	-
$LnDeposit_{i,t}$	Natural Logarithm of Deposits	+
$CART1_{i,t}$	$\frac{Tier\ 1\ Capital}{Risk\ Wheighted\ Assets}$	+
$GDP_{i,t}$	Annual Gross Domestic Product growth at constant price	+

Table 3. Source: Own elaboration.

3.3 Data description.

This paragraph is dedicated to the description of the data used in the construction of the banks sample: the chosen criteria, the time frame of analysis, and the databases used in the data recovery.

3.3.1 Databases and source of data.

The Databases used in this research are mainly two: ORBIS and Eikon – LSEG (ex Refinitiv) Workspace. The ORBIS database is used to obtain the data about the annual ratio of the banks (Non-performing Loans over Gross Loans, Equity over Total Assets and ROAA). The Eikon database is used to collect several bank data: all the banks' balance sheet items and ratio (Assets, Deposits and Capital Adequacy Ratio), the historical data of the Price to Book ratio, the ESG scores and each ESG Pillar score.

Lastly, it' used the World Bank database to obtain data about the annul real GDP growth rate of the countries where the banks have their headquarters.

The sample of banks chosen for this study is from the list of banks identified as systemically important by the European Banking Authority (EBA) in 2018, where this means that these are financial institutions that are more likely to create risks to the financial stability due to their systematic importance.

The list is composed by 177 banks but, as it is written in the following paragraphs, the samples to test the two models are composed by a lower number due to data availability and the exclusion of the bank branches outside the bank headquarter country due to the fact that these data are already presented in the balance sheet of the headquarter bank.

3.3.2 Z-score banks sample.

The sample of banks to test the influence of the Z-score on the Price to Book ratio is composed by 45 banks for a total of 745 observations. The period of time taken into consideration starts from 2006 and ends in 2023 for the majority of the banks sample, some banks have data starting after 2006. There are presented banks from 24 European countries. In Table 4 it's presented the list of the countries and banks presented in the sample.

Country	Banks
Austria	• Erste Group Bank AG • Raiffeisen Bank International AG
Belgium	• KBC Groep
Bulgaria	• First Investment Bank
Cyprus	• Bank of Cyprus Public Company Ltd • Hellenic Bank Public Company Ltd
Czech Republic	• Komercnì banka a.s.
Germany	• Deutsche Bank AG • Commerzbank AG
Denmark	• Danske Bank A/S • Jyske Bank A/S • Sydbank A/S • Spar Nord Bnak A/S

Spain	• Banco Santander S.A. • Banco Bilbao Vizcaya Argentaria S.A. • CaixaBank S.A. • Banco de Sabadell S.A. • Bankinter
Finland	• Nordea Bank
France	• BNP Paribas • Grouppe Credit Agricole • Societe Generale
Greece	• Eurobank Ergasias Services & Holdings S.A. • National Bank of Greece S.A. • Alpha Services and Holdings S.A.
Croatia	• Zagrabecka banka d.d Zagreb
Hungary	• OTP Bank Nyrt.
Ireland	• Bank of Ireland Group plc
Italy	• Unicredit Group • Gruppo Intesa San Paolo • Gruppo Monte dei Paschi di Siena • Banca Popolare di Sondrio
Lichtenstein	• Liectensteinische Landesbank AG
Malta	• Bank of Valletta plc
Netherlands	• ABN AMRO Banks N.V.
Norway	• DNB Bank ASA
Poland	• Bank Polska Kasa Opieki SA • mBank SA • Bank Handlowy w Warszawie SA
Portugal	• Banco BPI
Romania	• Banca Transilvania S.A.
Sweeden	• Skandinaviska Enskilda Banken AB • Svenska Handelsbanken AB • Swedbank AB
Slovakia	• Tatra banks a.s.

Table 4. Source: own elaboration.

3.3.3 ESG score banks sample.

The sample to test the effect of the ESG score on the Price to Book value is composed 35 banks for a total of 553 observations that cover, with the exception of some banks, the period from 2006 to 2023. The reason for the reduction of the sample respect to the one of the Z-score is due to the absence of ESG scores for some banks. The number of European countries presented in the banks' sample is 15. In the following Table 5 it's presented the list of banks and the countries covered by the sample.

Country	Banks
Austria	• Erste Group Bank AG • Raiffeisen Bank International AG
Belgium	• KBC Groep
Cyprus	• Bank of Cyprus Public Company Ltd
Germany	• Deutsche Bank AG • Commerzbank AG
Denmark	• Danske Bank A/S • Jyske Bank A/S • Sydbank A/S • Spar Nord Bnak A/S
Spain	• Banco Santander S.A. • Banco Bilbao Vizcaya Argentaria S.A. • CaixaBank S.A. • Banco de Sabadell S.A. • Bankinter
Finland	• Nordea Bank
France	• BNP Paribas • Grouppe Credit Agricole • Societe Generale
Greece	• Eurobank Ergasias Services & Holdings S.A. • National Bank of Greece S.A. • Alpha Services and Holdings S.A.
Ireland	• Bank of Ireland Group plc
Italy	• Unicredit Group • Gruppo Intesa San Paolo

	• Gruppo Monte dei Paschi di Siena • Banca Popolare di Sondrio
Norway	• DNB Bank ASA
Poland	• Bank Polska Kasa Opieki SA • mBank SA • Bank Handlowy w Warszawie SA
Romania	• Banca Transilvania S.A.
Sweeden	• Skandinaviska Enskilda Banken AB • Svenska Handelsbanken AB • Swedbank AB

Table 5. Source: own elaboration.

4 Chapter 4: Models analysis and tests.

This chapter is dedicated to the analysis of the models and to the discussion of their results. The chapter is divided into two main sections: the first one dedicated to the analysis of the effect of Z-score while the second one dedicated to the effect of the ESG Score on the Price-to-Book ratio.

The analysis are focused on the use of panel data and the models presented are Pooled OLS estimator, Random effect estimator (RE) and Fixed Effects estimator (FE).

4.1 Assumptions of the statistical models.

As it said above, the study is focused in the analysis of panel data, the different regressors presented exploit the different variations between the individuals (banks in this case). There are three types of variations: "overall", "between" and "within": with overall variation is intended the variations over time and over individuals: $x_{it} - \bar{x}$, where x_{it} is the individual value and $\bar{x}$ is the overall mean of the sample; with between variation is indicated the variation between individuals: $\bar{x}_i - \bar{x}$, where $\bar{x}_i$ is the individual mean and with within variation is indicated the variation within individuals over time: $x_{it} - \bar{x}_i$. The three estimators used in this analysis (Pooled OLS, Fixed Effect and Random Effect) exploit these variations between the individuals to estimate the parameters.

The estimators differ from each other for the different assumptions on the error term u_{it} and the unobserved fixed effect f_i: with unobserved effect is intended an unobserved, time-constant variable (as indicated by the lack of time dimension in f_i) that captures unobserved firm characteristics, such as managerial quality or structure, that are constant over the time of the analysis (Woolridge).

The descriptions of the estimators and their assumptions are the following:

- Pooled OLS estimator: weak exogeneity, $\mathbb{E}(u_{it}|\boldsymbol{x}_{it}, f_i) = 0$ and so $\mathbb{E}(\boldsymbol{x}'_{it} u_{it}) = 0$ and $\mathbb{E}(u_{it} f_i) = 0$ and no correlation between the unobserved fixed effect and the independent variables: $\mathbb{E}(f_i|\boldsymbol{x}_{i1}, \dots, \boldsymbol{x}_{iT}) = \mathbb{E}(f_i) = 0$. The Pooled OLS estimator uses both between and within variation to estimate the parameters and it stacks the data over *i* and *t* into one long regression.
- The Random Effect estimator: strict exogeneity, $\mathbb{E}(u_{it}|\boldsymbol{x}_{it}, \dots, \boldsymbol{x}_{iT}, f_i) = 0$ which implies $\mathbb{E}(\boldsymbol{x}'_{it} u_{it}) = \mathbf{0}$, for $s, t = 1, .. T$ and $\mathbb{E}(u_{it} f_i) = 0$ and no correlation between f_i and the independent variables $\boldsymbol{x}_{it}$.

- The Fixed Effect: it uses within variation and it assumes strict exogeneity and no restrictions on the correlation between f_i and $\boldsymbol{x}_{it}$ for $t = 1, \dots, T$.

4.2 Z-score analysis.

This part is focused on the analysis of the effect of the Z-score on the Price-to-Book ratio. In the following paragraphs are presented the summary of the statistics, the correlations, the models and the regressions results.

In the following table are presented the summary statistics of the variables, both independent and dependent, presented in the model.

Variable		Mean	Std. Dev.	Min	Max	Observations		
id	overall	23.53826	12.89407	1	45	N	=	745
	between		13.13393	1	45	n	=	45
	within		0	23.53826	23.53826	T-bar	=	16.5556
Year	overall	2014.846	5.124164	2006	2023	N	=	745
	between		1.483548	2014.5	2020	n	=	45
	within		5.014529	2005.971	2023.346	T-bar	=	16.5556
PB	overall	1.015973	.7346499	.07	7.96	N	=	735
	between		.3773942	.3628571	1.937778	n	=	45
	within		.6319822	-.241805	7.593751	T-bar	=	16.3333
Zscore	overall	20.45205	11.48936	-.7712112	61.64955	N	=	745
	between		11.0843	2.395827	50.92202	n	=	45
	within		3.449833	6.278555	37.31655	T-bar	=	16.5556
lnAsset	overall	25.44861	1.734783	21.46686	28.61076	N	=	745
	between		1.705543	22.22369	28.35709	n	=	45
	within		.2981798	23.61432	26.69761	T-bar	=	16.5556
ROAE	overall	.0697429	.2430366	-5.204812	.6411736	N	=	745
	between		.1108541	-.5439263	.1860898	n	=	45
	within		.226106	-4.591143	.9664098	T-bar	=	16.5556
NPLs	overall	7.245021	9.120233	0	59.20029	N	=	724
	between		6.535	.3860452	27.47171	n	=	45
	within		6.40671	-15.53234	38.9736	T-bar	=	16.0889
lnDeposits	overall	24.99866	1.520913	19.10851	27.85478	N	=	744
	between		1.467451	22.06591	27.52119	n	=	45
	within		.3841399	18.48412	26.28617	T-bar	=	16.5333
CART1	overall	.1570253	.1342108	.037	1.661	N	=	663

	between		.0679992	.1089333	.5712056	n	=	44
	within		.1126731	-.3112802	1.24682	T-bar	=	15.0682
GDP	overall	.0157402	.036578	-.1094007	.1625561	N	=	745
	between		.0151383	-.0075574	.0701965	n	=	45
	within		.0340254	-.1097563	.1295247	T-bar	=	16.5556

Table 6. Summary statistics Z-score regression. Own elaboration.

In Table 6 it's possible to observe all the variables of the regression together with the variable "id" and "Year" which were used to organize the panel data in the STATA software. They are also presented the overall, the between and within variations that are used in the panel data regressions. The id variable, used for the identification of the banks in the panel data has a within variation of 0, which is normal given the fact that the identification number of the bank doesn't change throughout the regression period. All the variations presented above are used in the regressions models such as: the Pooled OLS estimator, the Fixed Effect estimator and the Random Effect estimator.

An important limitation of the estimates in the regressions are the number of banks presented in the data: in panel data analysis to obtain consistent estimators it's necessary that the number of individuals (in this case banks) goes to infinity for a fixed T (number of periods); for reasons of data availability the number of banks analyzed is 45.

In order to see if the variables have multicollinearity problem, in Figure 12 are presented the correlations between the variables. The results show no particular high correlation results with the exception of the correlation between the logarithm of Asset and the logarithm of Deposit, resulting in 0.9785. This is plausible due to the fact that a bank with a large size and so, with an elevated number of assets, is likely to have also an elevated number of deposits.

	PB	Zscore	lnAsset	ROAE	NPLs	LnDepo~t	CART1	GDP
PB	1.0000							
Zscore	0.1730	1.0000						
lnAsset	-0.1670	0.0911	1.0000					
ROAE	0.1702	0.1750	-0.0312	1.0000				
NPLs	-0.2508	-0.4083	-0.2475	-0.1678	1.0000			
LnDeposit	-0.1737	0.0495	0.9785	-0.0237	-0.2151	1.0000		
CART1	-0.0529	0.0061	-0.1818	0.0400	0.1052	-0.1067	1.0000	
GDP	0.1985	0.0646	-0.1160	0.1118	-0.1054	-0.1153	-0.0147	1.0000

Figure 12. Correlation between the regressors of the Z-score analysis model. Own elaboration.

4.2.1 Z-score regression and coefficients.

To study the effect of the Z-score on the Price to Book value of the European banks is used the following model:

Model 1

$$P/B_{i,t} = \beta_0 + \beta_1 Z - score_{i,t} + \beta_2 \ln Asset_{i,t} + \beta_3 ROAE_{i,t} + \beta_4 NPLs_{i,t} + \beta_5 \ln Deposits_{i,t} + \beta_6 CART1_{i,t} + \beta_7 GDP_{i,t} + \sum_{i=2006}^{T} \delta_t Year_t + v_{i,t}$$

$$with\ v_{it} = f_i + u_{it}$$

The term v_{it} is composed by two elements: the fixed effect f_i which is an individual unobserved effect that doesn't change over time and the error term u_{it}. The variables $\sum_{i=1}^{T} \delta_t Year_i$ are years dummy to account for aggregate changes over time, in this case are one for every year between 2006 and 2023.

The results of the regressions of Model 1 are listed in Table 7.

	POOLED OLS	FIXED EFFECT	RANDOM EFFECT
Z-score	.0070391 *	-.0015759	.0069473 **
lnAsset	-.1993652	.3434074 ***	-.0398362
ROAE	.0851171	-.008239	.0296512
NPLs	-.0170769 ***	-.0099736 ***	-.0133542 ***
lnDeposits	.1470902	-.4638226 ***	-.0342033
CART1	.0039927	-.3274054 *	-.2045551
GDP	1.911032	-.0041527	.8673862
Constant	3.946686 ***	5.598833 **	4.467989 ***
Observations	637	637	637
R-squared	0.4582	Overall: 0.3405	Overall: 0.4443

		Between: 0.0566 Within: 0.4821	Between: 0.3984 Within: 0.4668

*Table 7. Summary of Model 1 regression coefficients and their level of significance. (***: 1% significance; **: 5% significance; *: 10% significance).*

The Z-score regressor shows a positive effect on the P/B ratio and it is significant at the 10% level in the Pooled OLS regression (p-value = 0,053) and at the 5% level in the Random Effect regression (p-value = 0,013). It shows a negative effect in the Fixed Effect estimator but it is not significant. The variable lnAsset is significant only in the FE regression and it shows a negative effect, in contrast with the positive, but not significant, effect in the Pooled OLS and RE estimators. ROAE is insignificant in all three regressions. The variable NPLs is significant in all three regressions at 1% level, showing a consistent negative effect on the P/B ratio. lnDeposits is significant at the 1% level only in the FE regression, and it shows no significance in the Pooled OLS or in the RE. Similar results although with a significance at 10% level for the variable CART1. GDP shows no significance.

To understand which estimator is more suitable is useful to compute the Hausman Test. The hypothesis presented in the test are:

- H_0: $\mathrm{E}(f_i|\boldsymbol{X}_i) = 0$, the RE estimator is consistent and efficient, whereas the FE estimator is consistent but inefficient.
- H_1: $\mathrm{E}(f_i|\boldsymbol{X}_i) = g(\boldsymbol{X}_i)$ and the RE estimator is inconsistent, whereas the FE estimator is consistent.

The result of the test is shown in the following figure:

```
Test of H0: Difference in coefficients not systematic

   chi2(24) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            = 2593.57
Prob > chi2 =  0.0000
(V b-V B is not positive definite)
```

Figure 13. Hausman test result for Model 1 regression. Own elaboration.

The p-value is equal to 0.0000 resulting in the rejection of the null hypothesis and in the choice of the Fixed Effect estimator. This indicates also that if the effects that don't change over time are eliminate, the Z-score shows no results.

Another test is the Breusch-Pagan test. This test helps in the choice between the Pooled OLS regressor and the RE regressor. The test hypothesis are the following:

- H_0: The random effect are insignificant and can be excluded from the model without a substantial lost of information.
- H_1: The random effect are significant.

The result of the test is determined by the p-value: for a p-value > 0,05 the null hypothesis is accepted and the Pooled OLS is the more appropriate regressor; for a p-value < 0,05 the RE is chosen.

The result of the Breusch-Pagan test is in the following Figure 14.

```
Breusch and Pagan Lagrangian multiplier test for random effects

        PB[id,t] = Xb + u[id] + e[id,t]

        Estimated results:
                         |       Var     SD = sqrt(Var)
                ---------+------------------------------
                      PB |   .4460833       .6678947
                       e |   .1895079        .435325
                       u |   .0257983       .1606184

        Test: Var(u) = 0
                                   chibar2(01) =   160.33
                                Prob > chibar2 =   0.0000
```

Figure 14. Breusch-Pagan test of the Model 1. Own elaboration.

It's possible to observe that the p-value is equal to 0,0000 meaning that it's preferable to use the Random effect model over the Pooled OLS model.

Given the limitation of the model due to the size of the sample, it's useful to try to extract more information making another regression: in fact it's easy to expect that the effect of the Z-score on the Price to Book ratio is subject to a temporal lag due to the time taken by the information to be absorbed into the market price. The data are annual so to see the effect it's necessary to regress the P/B ratio with the Z-score with a one year lag.

The model is the following:

Model 2

$$P/B_{i,t} = \beta_0 + \beta_1 Z - score_{i,t-1} + \beta_2 \ln Asset_{i,t} + \beta_3 ROAE_{i,t} + \beta_4 NPLs_{i,t}$$

$$+ \beta_5 \ln Deposits_{i,t} + \beta_6 CART1_{i,t} + \beta_7 GDP_{i,t} + \sum_{i=2006}^{T} \delta_t Year_t + v_{i,t}$$

$$with\ v_{it} = f_i + u_{it}$$

The temporal lag is expressed in the Z-score variable whereas the other variables maintain the original time.

The results are the following:

	POOLED OLS	FIXED EFFECT	RANDOM EFFECT
Z-score(t-1)	.0080648 **	.0046809	.0087248 ***
lnAsset	-.1951575	.2087483 *	-.0818587
ROAE	.7335289 **	.363164 *	.5187448 ***
NPLs	-.013583 ***	-.0086635 ***	-.0110184 ***
lnDeposits	.1431329	-.2542613 **	.0146939
CART1	-.0607942	-.3747886 **	-.2763786 *
GDP	1.960598 *	.4986837	1.073213
Constant	3.229588 ***	3.078293	3.612397 ***
Observations	614	614	637
R-squared	0.4478	Overall: 0.3135 Between: 0.2010 Within: 0.4083	Overall: 0.4327 Between: 0.4955 Within: 0.3946

*Table 8. Summary of Model 2 regression coefficients and their level of significance. (***: 1% significance; **: 5% significance; *: 10% significance).*

Confronting this results with those in Table 7, it's possible to observe an increase in significance of the Z-score: the $Z - score_{it-1}$ is significance at 5% level in the Pooled OLS regressor and at 1% level in the Random effect regressor, in contrast with the non-lagged $Z - score_{it}$ significant at 10% level in the Pooled OLS and 5% in the RE. lnAsset remains significant in the FE regressor although at 10% level. ROAE in the lagged Z-score regression is significant in all three regressor from 10% in the FE, to 5% in the Pooled OLS and at 1% level in the RE regressor. NPLs maintains its high significance at 1%. lnDeposits remains significant only in the FE regressor but at 5% level. CART1 increases its significance at 5% in the FE and at 10% in the RE. GDP variable becomes significant at 10% level in the Pooled OLS .

The result of the Hausman test is the following:

```
Test of H0: Difference in coefficients not systematic

   chi2(23) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =   4.40
Prob > chi2 = 1.0000
(V_b-V_B is not positive definite)
```

Figure 15. Hausman test result for Model 2 regression. Own elaboration.

In this case the test clearly indicates the Random Effect as a better regressor than the Fixed Effect, with a p-value of 1,000 the null hypothesis is not rejected.

The Breusch-Pagan test confirms the choice of the RE estimator as the result shows in the next figure:

```
Breusch and Pagan Lagrangian multiplier test for random effects

        PB[id,t] = Xb + u[id] + e[id,t]

        Estimated results:
                         |       Var     SD = sqrt(Var)
                ---------+-----------------------------
                      PB |   .3111722        .5578282
                       e |   .1256985        .3545398
                       u |   .0208605        .1444317

        Test: Var(u) = 0
                                  chibar2(01) =   231.59
                              Prob > chibar2 =   0.0000
```

Figure 16. Breusch-Pagan test for Model 2. Own elaboration.

The use of the one year lag Z-score in the regression leads to a more unequivocal results in the choice of the Random Effect regressor as shown by the Hausman test and by the Breusch-Pagan test also the significance is at 1% level. The results are discussed in more detail in the next paragraph.

4.2.2 Z-score models results.

This part is dedicated to the presentation of the results and the effect of the regressors. Also there is a comparison between the effects obtained in this study and the effects expected obtained in the literature.

- **Z-score**: as said before, this score shows the solidity of a bank, a higher score indicates a more solid banking institute and thus it's expected that this characteristic is appreciated by the market through a higher P/B value, although the absence of direct evidence due to the lack of papers found on this subject, this seems a reasonable and logic assumption. The results of this study shown a positive relation between P/B ratio and Z-score: in the

first model both the Pooled OLS regressor and the RE regressor have positive and significant sign, with significance of 10% and 5% respectively. A negative sign is registered on the FE regressor but its effect registered no significance. Both Pooled OLS and RE regressor show a very modest but positive contribution of roughly 0,007 to the P/B of the bank. This modest result can be due to the amount of data collected and the limited sample size for a panel data study. Nevertheless, in order to extract the maximum information possible the regression is also conducted using the lagged one year Z-score: in fact, the data are taken with annul frequency and the effect of an improvement (or deterioration) of the Z-score can be reflected on the P/B ratio with a time delay. For this reason also the model with a lagged one year Z-score is tested. The Z-score lagged model shows an improvement of the previous results: the Pooled OLS coefficient is equal to 0,0080648 with a significance of 5% whereas the RE coefficient is equal to 0,0087248 with a significance of 1%; the Fixed Effect is also positive but not significant. Also the Hausman and the Breusch-Pagan test indicate in a more decisively way the RE coefficient and thus the positive effect of the Z-score.

- **lnAsset**: the effect of this variable on the P/B ratio is more ambiguous: in the early 2000s a bank with significative dimension was considered more profitable and stable, this view changed after the financial crisis (Calomiris and Nissim, 2014), the size effect becomes insignificant (Bogdanova et al. 2018) or even negative (Ferretti et al. 2018; Markoulis et al. 2025). In the first Z-score model, lnAsset shows a positive effect of 0,3434074 with a significance of 1% in the FE regressor whereas the other two regressors, Pooled OLS and RE result in a negative effect, although not significant. A similar result is obtained in the lagged Z-score model where the only significant effect is the positive one in the FE regressor with a significance of 10%, the other two coefficients, the positive Pooled OLS and the negative RE are not significant.
- **ROAE**: this variable shows no significance in the first Z-score model: both the Pooled OLS regressor and the RE regressor registered a positive but not significant coefficient; the FE regressor results in a negative, not significant coefficient. This outcome changes in the other lagged model, where all the regressors registered a positive and significant coefficient: the Pooled OLS is equal to 0.7335289 at 5% significance, the FE regressor is equal to 0,363164 at 10% significance and the RE regressor results in 0,5187448 at a level of significance of 1%. The results of the second regression are more in line with the expectation of the ROAE variable, in fact it's reasonable to expect that a high return on asset corresponds to a higher market valuation and so a higher P/B ratio.

- **NPLs**: the effect of the Non-Performing Loans is undoubtedly the clearest between all the variables examined. It shows a significative and negative effect in all the regressors of the two models: in the first regression the effect is negative and significant at 1% level in all the regressor resulting in a coefficient equal to -0,170769 in the Pooled OLS regressor, -0,0099736 in the FE and -0,0133542 in the RE. Again in the lagged Z-score model variable still be negative and significant at 1% level, resulting in a -0,013583 in the Pooled OLS regressor, -0,0086635 in the FE and -0,0110184 in the RE. These results are in line with the expectation of its effect and with the results obtained in the literature. A high level of non-performing loans continues to have a relevant significative negative effect on the valuation of a bank market price.
- **lnDeposits**: the results obtained for this variable are similar for the two models tested: both the Pooled OLS regressors of the first model and the lagged one are positive but not significant, the RE regressor of the Z-score model is negative (-0,342033) but not significant, whereas the one of the lagged version in positive but still not significant (0,0146939). For the FE regressors, both models show a negative and significative effect: in the first model it's obtained a coefficient equal to -0,4638226 with a significance at a 1% level, in the lagged model the coefficient is equal to -0,2542613 with a 5% significance. This results are in contrast with the expectation of a positive effect but in line with the results of Calomiris and Nissim (2014).
- **CART1**: the variable shows negative coefficients, in contrast with the positive expectations about its effect. It was assumed that a higher Capital Adequacy Ratio corresponds to a higher market valuation due to the higher solidity of the bank. In the first regression the FE regressor is equal to -0,3274054 and with a 10% significance. The Pooled OLS and RE show no significance. In the lagged Z-score model all the regressors show a negative coefficient: the Pooled OLS, the only one not significant is equal to -0.0607942, whereas the FE results in -0.3747886 with 5% significance and the RE is equal to -0.2763786 with 10% significance. It's possible to deduce that a higher CART corresponds to a higher risk in the asset of the bank and so in a higher risk perception of the banking institution leading to a lower market valuation.
- **GDP**: the results shows that the coefficient of the two models are all positive with the exception of the FE regressor in the first model although only the Pooled OLS of the lagged Z-score model is significant at 10% level. On one hand this result goes in the direction of the literature findings, on the other hand the significance doesn't meet the expectation of a strong significance. This can be caused by the nature of the data or by

the fact that a lot of the banks in the sample have branches in other European countries making the GDP of the country where they have the headquarter not so relevant.

In conclusion the study shows a positive effect of the Z-score on the Price-to-Book ratio: this results is reasonable, in fact it's logical to expect that the market would reward the solidity of a banking institution, express by a high Z-score, with a higher price than another bank with a lower Z-score. The magnitude of this effect found in this model, although significant, is not high: an increase of 0,0087248 in the P/B for an increase of one unit of the Z-score. This can be caused by the nature of the data used in the model and by the numerosity of the sample in a panel data regression. In the Appendix the role of the Z-score is explored further by taking another two regressions using a model composed only by the Z-score and the Z-score lagged as independent variables.

4.3 ESG score analysis.

In this section it's analyzed the effect of the ESG score on the Price-to-Book ratio of the European banks: it's taken into consideration not only the overall ESG score in the analysis but also the singular components of the ESG score: the Environmental Score, the Social Score and the Governmental Score; in this way it's possible to break down the ESG score and to observe the singular effect of the three components, giving the fact that from the literature the singular scores have different effect on the bank market valuation.

Variable		Mean	Std. Dev.	Min	Max	Observations		
id	overall	18.34177	9.993513	1	35	N	=	553
	between		10.24695	1	35	n	=	35
	within		0	18.34177	18.34177	T-bar	=	15.8
Year	overall	2015.105	5.120985	2006	2023	N	=	553
	between		1.973385	2014.5	2020.5	n	=	35
	within		4.923187	2005.971	2023.605	T-bar	=	15.8
PB	overall	.9515876	.6704618	.07	7.96	N	=	548
	between		.3210978	.3628571	1.660625	n	=	35
	within		.5960707	-.1906346	7.529365	T-bar	=	15.6571
ESGscore	overall	64.035	19.29717	3.7	95.68068	N	=	553
	between		16.26442	23.08831	85.69567	n	=	35
	within		10.74081	28.18531	92.53956	T-bar	=	15.8
Env	overall	77.19798	21.02701	15.25974	98.31015	N	=	553
	between		16.34398	34.73227	94.29349	n	=	35
	within		14.45688	18.18299	119.2758	T-bar	=	15.8
Soc	overall	65.3893	20.5157	2.716469	97.66093	N	=	553
	between		15.85113	22.66561	85.93329	n	=	35
	within		12.90625	20.39788	95.34845	T-bar	=	15.8
Gov	overall	62.22137	22.96043	1.884058	94.8913	N	=	553
	between		19.71764	19.7541	87.26112	n	=	35
	within		12.59094	21.38504	104.2436	T-bar	=	15.8
lnAsset	overall	26.09441	1.430926	22.97362	28.61076	N	=	553
	between		1.486448	23.18719	28.35709	n	=	35
	within		.261742	24.26012	27.00948	T-bar	=	15.8
ROAA	overall	.4851803	.9649078	-10.83618	4.429267	N	=	553
	between		.5301786	-.5282531	1.871523	n	=	553
	within		.8336578	-9.822747	5.124721	T-bar	=	15.8
NPLs	overall	6.712259	8.745834	.0868904	53.2876	N	=	539

	between		6.111502	.3860452	26.64105	n	=	35
	within		6.220484	-16.0651	33.3588	T-bar	=	15.4
lnDeposits	between	25.53471	1.292471	19.10851	27.85478	N	=	552
	within		1.275538	22.89586	27.52119	n	=	35
	overall		.3978489	19.02017	26.82222	T-bar	=	15.7714
CART1	between	.1429334	.0418581	.037	.289	N	=	506
	within		.0256118	.1089333	.20174	n	=	35
	overall		.0339182	.0221934	.2366209	T-bar	=	14.4571
GDP	between	.0138812	.0353625	-.1094007	.1625561	N	=	553
	within		.0150206	-.0035579	.0701965	n	=	35
	overall		.0332789	-.1116153	.1062409	T-bar	=	15.8

Table 9. Summary statistics ESG score regression. Own elaboration.

In Table 9 there is the summary of the variables that are used in the following models and their relative variations. It's useful to remember that the number of banks in this sample is 35 and the observations are taken between 2006 and 2023.

As said above, for this analysis two models are used: one with the ESG score and the other with its components, plus the controls variables. This is due to the fact that putting both the ESG score and its components in one regression would cause multicollinearity problems for the obvious reason that the components of the ESG score contribute to the formation of the ESG score itself.

4.3.1 ESG score regression and coefficients.

The first model analyzed take into consideration the ESG score as a whole, not distinguishing between its components, the model is the following:

Model 3

$$P/B_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 \ln Asset_{i,t} + \beta_3 ROAA_{i,t} + \beta_4 NPLs_{i,t} + \beta_5 \ln Deposits_{i,t}$$

$$+ \beta_6 CART1_{i,t} + \beta_7 GDP_{i,t} + \sum_{i=2006}^{T} \delta_t Year_t + v_{i,t}$$

$$with\ v_{it} = f_i + u_{it}$$

As in the models before, the term v_{it} is composed by two elements: the fixed effect f_i which is an individual unobserved effect that doesn't change over time and the error term u_{it}. The variables $\sum_{i=1}^{T} Year_i$ are years dummy to account for aggregate changes over time. In Figure 17 there are the correlations between the variables of the Model 3: the highest correlations of the ESG scores are registered with the variables that express size, the lnAsset (0,6399) and lnDeposit (0,6716). This indicates that larger banking institutions put more effort in the

improvement of the relation with their stakeholders as shown in the "stakeholder view" whereas this is not a priority in banks with smaller dimensions.

	PB	ESGscore	lnAsset	ROAA	NPLs	LnDepo~t	CART1	GDP
PB	1.0000							
ESGscore	-0.2389	1.0000						
lnAsset	-0.1924	0.6399	1.0000					
ROAA	0.3849	-0.1356	-0.2107	1.0000				
NPLs	-0.2394	-0.0703	-0.2162	-0.4066	1.0000			
LnDeposit	-0.2226	0.6716	0.9759	-0.1956	-0.1774	1.0000		
CART1	-0.0138	0.0547	-0.1876	0.2101	-0.0662	-0.2224	1.0000	
GDP	0.1689	-0.0470	-0.1345	0.2485	-0.1107	-0.1335	0.1513	1.0000

Figure 17. Correlation between Model 3 variables. Own elaboration.

The results of the regression are shown in the following table:

	POOLED OLS	FIXED EFFECT	RANDOM EFFECT
ESGscore	.0011347	-.0059058 **	.000539
lnAsset	-.1590414	.6782839 ***	-.0307518
ROAA	.1296078 **	.0690025 *	.1157782 ***
NPLs	-.0141152 ***	-.0048971	-.0106932 ***
lnDeposits	.097648	-.6614887 ***	-.0432206
CART1	4.646173 ***	2.15869 *	4.048726 ***
GDP	-.0966101	-1.348375	-.4841899
Constant	3.926093 ***	2.096632	4.269866 ***
Observations	490	490	490
R-squared	0.5008	Overall: 0.3157 Between: 0.0187 Within: 0.5032	Overall: 0.4955 Between: 0.6239 Within: 0.4701

*Table 10. Summary of Model 3 regression coefficients and their level of significance. (***: 1% significance; **: 5% significance; *: 10% significance).*

The ESG score shows no significance in the Pooled OLS regressor and in the RE regressor, the only significant (at 5% level) effect is registered in the FE regressor with -0.0059058, so a very small negative effect on the P/B ratio. In order to check which regressor is the most suitable the Hausman test is performed:

```
Test of H0: Difference in coefficients not systematic

   chi2(24) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  71.91
Prob > chi2 = 0.0000
(V_b-V_B is not positive definite)
```

Figure 18. Hausman test result for Model 3 regression. Own elaboration.

With a p-value equal to 0,0000 the null hypothesis is rejected and so the FE is selected as the most suitable regressor.

The data are taken with annual frequency, so as it was done for the Z-score, it's logical to expect that a change in the ESG score reflects its consequences on the P/B ratio after some time. For that reason it's useful also to analyze the regression with a one year lagged ESG score as it's presented in the following model:

Model 4

$$P/B_{i,t} = \beta_0 + \beta_1 ESG_{i,t-1} + \beta_2 \ln Asset_{i,t} + \beta_3 ROAA_{i,t} + \beta_4 NPLs_{i,t} + \beta_5 \ln Deposits_{i,t}$$

$$+ \beta_6 CART1_{i,t} + \beta_7 GDP_{i,t} + \sum_{i=2006}^{T} \delta_t Year_t + v_{i,t}$$

$$with\ v_{it} = f_i + u_{it}$$

The regression results are shown in the following table:

	POOLED OLS	FIXED EFFECT	RANDOM EFFECT
ESGscore(t-1)	.0019667	-.005068 **	.0014294
lnAsset	-.2297797 *	.5171934 ***	-.1631659 **
ROAA	.1065727 *	.0477574 *	.0957437 ***
NPLs	-.0158067 ***	-.0078014 **	-.0141294 ***
lnDeposits	.1640288	-.0078014 ***	.0943353

CART1	5.273702 ***	3.336042 ***	4.948464 ***
GDP	.1277994	-1.348375	-.0527971
Constant	3.195461 ***	-.7213388	3.299882 ***
Observations	467	467	467
R-squared	0.4966	Overall: 0.1599 Between: 0.0045 Within: 0.4163	Overall: 0.4945 Between: 0.7504 Within: 0.3655

*Table 11.Summary of Model 4 regression coefficients and their level of significance. (***: 1% significance; **: 5% significance; *: 10% significance).*

The results of the lagged model (Model 4) give a similar outcomes of those obtained from Model 3: the only ESG significative effect is the negative one from the FE regressor. Also the lnAsset and ROAA variables shows similar outcomes although for the former not univocal: in fact the only significative effect (at 1% level) in Model 3 is registered in the FE regression whereas the negative coefficients of the Pooled OLS and RE regressors are not significative. Also in Model 4 the coefficient is positive and significative (at 1% level) but are significative also the Pooled OLS and RE regressors which have a negative effect. This makes the overall effect of the size difficult to read. A completely different matter is the ROAA coefficient which shows positivity and significance in all the regressors of the two models. NPLs variable is negative and significant in all the regressors with the exception of the FE regressor in Model 3. lnDeposits variable is negative and significant at 1% level in the FE regressor in both models. CART1 and GDP variables have identical signs and similar significance in both models.
As for the previous model, the Hausman test is reported:

```
Test of H0: Difference in coefficients not systematic

chi2(23) = (b-B)'[(V_b-V_B)^(-1)](b-B)
         = -2572.77
```

Figure 19. Hausman test for Model 4 regression. Own elaboration.

The test result in a negative χ^2, meaning that the model failed to meet the assumption of the Hausman test. This can be cause by the limited number of banks in the sample nad the limited variability that derived.

The ESG score is composed by three components: the Environmental Score, the Social Score and the Governance Score. Giving that this analysis is focused on the banking sector it's useful to see which of these three components exerts the major influence: in fact it's expected that different business and industrial sectors have different sensibilities about the fields that these scores measure increasing or decreasing their relevance in a market valuation.

Model 5

$$P/B_{i,t} = \beta_0 + \beta_1 Env_{i,t} + \beta_2 Soc_{i,t} + \beta_3 Gov_{i,t} + \beta_4 \ln Asset_{i,t} + \beta_5 ROAA_{i,t} + \beta_6 NPLs_{i,t}$$
$$+ \beta_7 \ln Deposits_{i,t} + \beta_8 CART1_{i,t} + \beta_9 GDP_{i,t} + \sum_{i=2006}^{T} \delta_t Year_t + v_{i,t}$$
$$with\ v_{it} = f_i + u_{it}$$

In Figure 20 it's possible to see the correlations between the variables of Model 5:

	PB	Env	Soc	Gov	lnAsset	ROAA	NPLs	LnDepo~t	CART1	GDP
PB	1.0000									
Env	-0.2785	1.0000								
Soc	-0.2669	0.7982	1.0000							
Gov	-0.0789	0.4378	0.5146	1.0000						
lnAsset	-0.1924	0.6815	0.6489	0.3497	1.0000					
ROAA	0.3849	-0.2342	-0.1710	0.0139	-0.2107	1.0000				
NPLs	-0.2394	-0.0397	-0.0452	-0.0753	-0.2162	-0.4066	1.0000			
LnDeposit	-0.2226	0.6882	0.6813	0.3805	0.9759	-0.1956	-0.1774	1.0000		
CART1	-0.0138	0.0749	0.0464	0.0078	-0.1876	0.2101	-0.0662	-0.2224	1.0000	
GDP	0.1689	-0.1080	-0.0397	-0.0208	-0.1345	0.2485	-0.1107	-0.1335	0.1513	1.0000

Figure 20. Correlations between Model 5 variables. Own elaboration.

Once again the highest correlation is registered between the variables expressing size: lnAsset and LnDeposit. Between the scores that compose the ESG Score the highest correlation value is registered between Social Score and Environmental Score with a value of 0,7982. Whereas the correlation between Environmental and Governance Score is equal to 0,4378.

The results of the Model 5 regression are the following:

	POOLED OLS	FIXED EFFECT	RANDOM EFFECT
Env	.0032254	.0014	.003361
Soc	.0000163	-.0029997	-.0006691
Gov	-.0006763	-.0027467	-.0008794

lnAsset	-.1875974	.6014857 ***	-.0482543
ROAA	.1351247 **	.0725022 **	.1169308 ***
NPLs	-.0143802 ***	-.0053256	-.0106469 ***
lnDeposits	.1111705	-.6140056 ***	-.0424583
CART1	4.637365 ***	2.189702 **	3.948024 ***
GDP	.1515809	-1.264931	-.3347813
Constant	4.250594 ***	2.842657	4.662287 ***
Observations	490	490	490
R-squared	0.5039	Overall: 0.3390 Between: 0.0351 Within: 0.5031	Overall: 0.4968 Between: 0.6014 Within: 0.4756

*Table 12. Summary of Model 5 regression coefficients and their level of significance. (***: 1% significance; **: 5% significance; *: 10% significance).*

As in Table 12 is shown, none of the singular components of the ESG score registered a level of significance above 10%. Other variables such as NPLs or ROAA shows results compatibles with those obtained from previous regressions. This can indicates the irrelevance of these measures in the market valuation of European banking institutions.

For completeness the Hausman test is reported in the following figure:

```
Test of H0: Difference in coefficients not systematic

   chi2(26) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  65.18
Prob > chi2 = 0.0000
(V_b-V_B is not positive definite)
```

Figure 21. Hausman test for Model 5. Own elaboration.

With a p-value equals to 0,0000 the null hypothesis is rejected and the FE estimator is indicated as the most suitable estimator.

As for the ESG score, the same argument regarding the time needed for the market to evaluate a change in the score can be applied to the components of the ESG score. This last regressions evaluates the effects of the one year lagged Environmental, Social and Government score on the Price-to-Book ratio.

For this purpose the model is the following:

Model 6

$$P/B_{i,t} = \beta_0 + \beta_1 Env_{i,t-1} + \beta_2 Soc_{i,t-1} + \beta_3 Gov_{i,t-1} + \beta_4 \ln Asset_{i,t} + \beta_5 ROAA_{i,t} + \beta_6 NPLs_{i,t} + \beta_7 \ln Deposits_{i,t} + \beta_8 CART1_{i,t} + \beta_9 GDP_{i,t} + \sum_{i=2006}^{T} \delta_t Year_t + v_{i,t}$$

$$with\ v_{it} = f_i + u_{it}$$

The results are summarized in the following table:

	POOLED OLS	FIXED EFFECT	RANDOM EFFECT
Env(t-1)	.003169	.0018134	.0033509 **
Soc(t-1)	.0006345	-.0022731	-.0001178
Gov(t-1)	-.000349	-.0032723 **	-.0005968
lnAsset	-.2509144 **	.45253 ***	-.1640665 **
ROAA	.1131557 *	.0521184 *	.0973399 ***
NPLs	-.0162074 ***	-.0083734 ***	-.0139982 ***
lnDeposits	.1673758	-.3663404 ***	.0763559
CART1	5.236733 ***	3.33496 ***	4.772743 ***
GDP	.3070676	-.6076442	.0441174
Constant	3.592849 ***	-.4903407	3.749062 ***

Observations	467	467	490
R-squared	0.5010	Overall: 0.1844 Between: 0.0110 Within: 0.4201	Overall: 0.4967 Between: 0.7272 Within: 0.3770

*Table 13. Summary of Model 6 regression coefficients and their level of significance. (***: 1% significance; **: 5% significance; *: 10% significance).*

The use of the delayed scores improved the slightly the significance of the variables: the Environmental Score has a positive effect of 0.0033509 and a significance at 5% level in the RE regressor; whereas the Governance Score has negative effect of -.0032723 with a significance of 5% level.

Lastly, the Hausman test is performed for Model 6:

```
Test of H0: Difference in coefficients not systematic

chi2(25) = (b-B)'[(V_b-V_B)^(-1)](b-B)
         = -73.78
```

Figure 22. Hausman test for Model 6 regression. Own elaboration.

As for the Hausman test of Model 4, the test of Model 6 fails to meet the assumptions required for the test. This is likely due to the insufficient size of the banks sample required for a more performative panel data analysis.

4.3.2 ESG Score models results.

This part is dedicated to the summary of the results obtained by the models in the previous part. In addition to the results obtained there are comparison between what is obtained and the expectations written in the previous section derived from the literature.

- **ESG Score**: this variable is analyzed in Model 3 where it is regressed in the same year of the P/B ratio and in Model 4 where it undergoes a one year time delayed. Both the two models record a significance at 5% level of the FE regressor with a negative impact on the Price-to-Book ratio of banks. These results indicate support for the "overinvestment view" (or "shareholder view") of the ESG score rather then the "stakeholder view" as indicated in di Tommaso and Thorton (2020). Although with the caution necessary due to the limitation of the models, above all the limitation of the sample size, it's safe to say that this is not an outcome that creates surprise: as the other variables show, the evaluation of the Price-to-Book ratio of the European banks is driven by other more conventional variables such as ROAA and NPLS.

- **Environmental Score**: component of the ESG Score. In the regressions of Model 5 it registered no significance, whereas in Model 6 it registered a positive effect with a 5% level of significance. Its overall impact on the P/B ratio is very marginal.
- **Social Score**: component of the ESG Score. The regression of Model 5 and Model 6 shows equal sign effect on the regressors but none of them is significant, indicating no effect on the P/B ratio.
- **Governance Score**: last component of the ESG Score. In all the regressions of Model 5 and Model 6 the coefficients have negative signs, only in the FE regressor of Model 6 the significance is relevant with a 5% level. This measurement, as for the other components of the ESG Score has a very limited impact on the P/B ratio of the European banks.
- **lnAsset**: control variable for the size of the banking institute. In Model 3 and Model 5 the variable has a positive and significant effect at 1% level, in both models, the other two types of regressions, Pooled OLS and RE, record negative effect but not significant. The situation becomes less clear in Model 4 and Model 6 where next to the positive and significant effect of the FE, there are the negative and significant effects of the Pooled OLS and RE, making the interpretation of the variable lnAsset not clear. This can be due to the construction of the model and the not sufficiently numerous sample size as the Hausman tests produces negative outcomes not meeting the requirements for the tests.
- **ROAA**: variable that controls for the profitability of the banks. In all the models proposed the coefficients record all positive and significant effect on the P/B ratio. This confirms the importance of variables that measure the profitability dimension of the banks in their market valuation.
- **NPLs**: variable that controls for the quality of the assets of the banks. Again this variable proves to be very important in the market valuation of banking institutes. In all the models presented it records negative signs and with the exceptions of Model 3 and Model 5 FE regressors it has a level of significance at 5% and 1%. This indicates that the maximum effect of the variable is recorded by the market with a time delay. Together with the variables that measure profitability, those that measure asset quality remain crucial in the P/B ratio valuation.
- **lnDeposits**: other control variable. Its results are once again in contrast with those presented in Calomiris and Nissim (2014). The coefficients shows negative and significant signs at 1% level in all the models presented.

- **CART1**: control variable that controls the solidity of a bank. All the coefficient obtained in the four models shows a significant and positive effect of this variable. This result, more in line with the expectation expressed about it, is in contrast with what is found in the models that analyzed the Z-score, where it shows a (weak) negative effect.
- **GDP**: last control variables of the models exanimated. The last variable taken into consideration. It shows no significance in any of the regressions of the models presented.

In conclusion the effect of the ESG Score on the Price-to-Book ratio is very marginal: from the ESG Score itself the results shows a negative effect supporting the "shareholder view": meaning that investments in improving the score are seen as a not effective resource allocation, instead of the more traditional investment in the core activity of the business. The low impact of the ESG is seen also in the regressions where the singular components of the score are tested: only Governance Score and Environmental Score registered respectively a negative and a positive effect but the magnitude is very low. What can be deduced is that in the market valuation of European banks the more classical variables regarding profitability and assets quality still play the main role of the valuation whereas the ESG Score plays a marginal role in the overall valuation.

5 Conclusion.

The objective of this study was to examine what influences the Price-to-Book ratio of the European banks other that the common accounting indexes.
In fact the literature is rich of studies that analyze the effects of variables such as Non-performing loans and indicators of profitability such as Return on Assets or Non-interest income and expenses on the P/B ratio of banks especially after the financial crisis of 2008. In order to analyze the topic taking a different path, the Z-score and the ESG Score were taken into consideration.
As said before, the Z-score is an indicator that expresses the solidity of a banking institution and different studies have analyzed it as a dependent variable: observing which accounting indexes and economic variables influenced the score. The main difference between this study and the previous ones is that, in this case, the object of interest is how and if the Z-score influences the Price-to-Book ratio and so its use as an independent variable. At the moment, it was not possible to find other researches or studies where the Z-score was used in this way. This has represented also a disadvantage as it was not possible to have previous data on the behavior of the Z-score in this role. Another difficulty encountered was the collection of the data: not all the banks initially identified have their accounting data saved or accessible in the available databases which were ORBIS and Eikon – LSEG (ex Refinitiv) Workspace. This made it possible to have a sample composed by 45 European banks, not a very high numbers of banks to realize a solid panel data analysis over the eighteen years time period taken into consideration.
Despite this factors it was possible to obtain some results that identified the Z-score as a variable that has a positive relation with the market valuation expressed by the Price-to-Book ratio. This outcome shows a logical reasoning: it's reasonable to expect that a bank perceived solid will obtain from the market a higher valuation, and consequently a higher P/B ratio, than a bank that have a lower degree of financial solidity, expressed by the Z-score.
Despite these results that show the existence of a link between the Z-score and the P/B ratio, more in-depth studies are necessary that require a more numerous sample of banks and the comparison with other geographical areas to see if it is possible to obtain more information about the magnitude of the effect.

The other relationship examined in this study is the one between the ESG Score and the P/B ratio of the European banks. As seen in the literature the ESG Score has undergone several

studies where the relationship with the banking industry has been analyzed. These studies focused not only on the market value but also on the risk and on the cost of debt.

The research conducted here focused on the market value of the European banking industry through the use of the Price-to-Book ratio. Once again the difficulty encountered concerned the gathering of the data: the database used for this purpose was Eikon-LSEG (ex Refinitiv) where it was possible to obtain the ESG Score and the single scores that compose it with annual frequency. Not all the banks provided complete data and for this reason the final sample is composed by 35 banks.

The models presented not only put into relation the ESG Score and its components with the P/B ratio of the same year but also the scores with one year lag: this was done to ensure the capture of all the possible effects, in fact using annual data it's likely that the effects of a change in the scores will be absorbed in the market valuation the following year. The results obtained show a negative effect of the ESG Score on the P/B ratio supporting the "overinvestment view" expressed in Di Tommaso and Thorton (2020). Regarding the singular scores, traces of significance were found in the Environmental Score and in the Governance Score, whereas the Social Score expressed no significance. What can be deduced is that these scores play a very limited role in the valuation of the European banking institutions, whereas indexes of profitability and assets quality such as ROAA and NPLs continue to be crucial in the market valuation. Due to the limitations of the data, in order to obtain more complete results this subject need to be studied thoroughly and with the use of a more large sample of European banks.

Appendix.

Z-score in-depth analysis.

In this part the effect of the Z-score on the Price-to-Book ratio is studied without the use of other control variables as in the previous analysis. The fact that no other studies could be found regarding the effect of the Z-score on the banks market valuation leave open many possibilities but also unknowns about how this effect is reflected on the P/B. It's possible that one reason of the reduced magnitude of the Z-score in the previous regressions of this study is due to the choice of control variables: in fact it's plausible that they reduced the significance of the Z-score leading to the results obtained above. For that reason the models proposed in this part take into account only the Z-score and the one year lagged Z-score as independent variable.

The models are the following:

Model 7

$$P/B_{i,t} = \beta_0 + \beta_1 Z - score_{i,t} + \sum_{i=2006}^{T} \delta_t Year_t + v_{i,t} \quad with\ v_{it} = f_i + u_{it}$$

Model 8

$$P/B_{i,t} = \beta_0 + \beta_1 Z - score_{i,t-1} + \sum_{t=2006}^{T} \delta_t Year_t + v_{i,t} \quad with\ v_{it} = f_i + u_{it}$$

The results are summarized in the following tables:

	POOLED OLS	FIXED EFFECT	RANDOM EFFECT
Z-score	.0109892 **	.004978	.0089521 **
Constant	2.365267 ***	2.454884 ***	2.383426 ***
Observations	735	735	735
R-squared	0.4198	Overall: 0.4113 Between: 0.2089 Within: 0.5071	Overall: 0.4189 Between: 0.2228 Within: 0.5067

*Table 14. Summary of Model 7 regression coefficients and their level of significance. (***: 1% significance; **: 5% significance; *: 10% significance).*

	POOLED OLS	FIXED EFFECT	RANDOM EFFECT
Z-score(t-1)	.0132214 ***	.005208	.0099311 ***
Constant	1.893978 ***	2.02064 ***	1.935084 ***
Observations	690	690	690
R-squared	0.3342	Overall: 0.3114 Between: 0.2331 Within: 0.4138	Overall: 0.3308 Between: 0.2499 Within: 0.4128

*Table 15. Summary of Model 8 regression coefficients and their level of significance. (***: 1% significance; **: 5% significance; *: 10% significance).*

In the following figures are presented the Hausman tests both for Model 7 and Model 8:

```
Test of H0: Difference in coefficients not systematic

   chi2(18) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =   1.24
Prob > chi2 = 1.0000
```

Figure 23. Hausman test of Model 7.

```
Test of H0: Difference in coefficients not systematic

   chi2(17) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =   2.43
Prob > chi2 = 1.0000
```

Figure 24. Hausman test Model 8.

From the results of the test it's possible to see that the null hypothesis is not rejected in both models and thus the RE estimator is the most suitable estimator.

This is also confirmed by the Breusch-Pagan test:

```
Breusch and Pagan Lagrangian multiplier test for random effects

        PB[id,t] = Xb + u[id] + e[id,t]

        Estimated results:
                         |       Var     SD = sqrt(Var)
                ---------+------------------------------
                      PB |   .5397105       .7346499
                       e |   .2150475       .4637322
                       u |    .117962       .3434559

        Test: Var(u) = 0
                                  chibar2(01) =   687.95
                              Prob > chibar2 =   0.0000
```

Figure 25. Breusch-Pagan test of Model 7.

```
Breusch and Pagan Lagrangian multiplier test for random effects

        PB[id,t] = Xb + u[id] + e[id,t]

        Estimated results:
                         |       Var     SD = sqrt(Var)
                ---------+------------------------------
                      PB |    .3472348       .5892663
                       e |    .1394728       .3734606
                       u |    .1023481       .3199188

        Test: Var(u) = 0
                                  chibar2(01) =   935.71
                               Prob > chibar2 =   0.0000
```

Figure 26. Breusch-Pagan test of Model 8.

From the comparison between the regressions of Model 1 and Model 2 and the ones with only the Z-score (Model 7 and Model 8), it's possible to see an increase in the level of significance (1% in Model 8 Z-score variable respect to 5% of the one in Model 2 for the Pooled OLS regressor). The highest Z-score coefficient is registered in the Pooled OLS regressor of Model 8 equals to 0,0132214. Although the tests suggest the RE coefficient as the most suitable, equal to 0,0099311 and significant at 1% level. What is deduced from these models is another confirmation of the positive effect of the Z-score on the Price-to-Book value: all the regressors effect are positive and those indicated by the tests are also all significant at least at 5% level. Undoubtedly more studies are needed to better understand the magnitude of the Z-score effect on the market valuation of banks with a wider sample.

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