Market competition and bank performance – empirical evidence from the European Union banking sector

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ABSTRACT

 The main aim of this paper is to empirically test the contribution of market competition to bank performance and the influence of the crises that affected the EU banking sector over the years 2006-2021. Using data sourced from the Moody's Analytics BankFocus database, the paper presents the results obtained with panel fixed, random, and dynamic GMM estimations. Bank performance is proxied with two variables: bank profitability and bank capitalization. Bank profitability is measured with the return on equity ratio, and bank capitalization is represented with the equity to total assets ratio. Bank competition is measured with Boone indicators and Herfindahl-Hirschman Indices. These two competition measures are separately computed for banks' profits, loans, and deposits. The findings suggest that competition, evaluated from an efficiency perspective, plays a more crucial role than market concentration in the banking sector in explaining bank performance. Furthermore, the profitability of banks does not appear to be directly linked to their traditional activities. The paper highlights the significant role of political and regulatory authorities in ensuring that legislation and conditions are in place to maintain bank market competition without exacerbating crisis risks while also fostering economic growth.

Highlights of this paper

- Competition in the banking sector significantly influences the performance of banks within the EU. The statistical correlation between market competition and bank profitability is particularly pronounced when using the Boone indicators, which assess competition from an efficiency standpoint.
- The findings concerning competition measures in the loans market align closely with those in the deposits market, indicating that there are no significant differences in how competition in traditional banking activities affects overall bank performance.
- However, the results related to competition measures and bank profits do not completely correspond with those observed in the loans and deposits markets. This suggests that banks' profits are not clearly linked to their traditional activities.

1. INTRODUCTION

Economic theory traditionally supports the notion that perfect information and robust market competition correlate with optimal performance. Conversely, market power concentration is typically associated with weak competition and poor performance. Competition within banking markets is believed to benefit clients by enhancing choices, reducing borrowing rates, and increasing deposit rates. However, it is acknowledged that the increasing globalisation and liberalisation of financial markets, coupled with worldwide technological advancements, have transformed the functional and competitive landscape of banking institutions.

Particular attention has been directed towards bank risk performance and the challenges posed by asymmetric information in financial markets, especially following the subprime crisis. To mitigate issues of adverse selection and moral hazard, there is an ongoing recommendation to enhance transparency and foster trust, primarily through establishing enduring relationships between banking institutions and their clients. Such long-lasting relationships, grounded in trust, are often associated with bank market power and can be seen as a crucial condition for effective bank performance.

In the European Union (EU), the global liberalisation process has coincided with initiatives to create a single European financial market, based on the belief that market competition would enhance bank performance. However, the subprime crisis severely impacted the European banking sector, leading many EU banks to incur substantial losses. Their survival was primarily reliant on extraordinary financial assistance from national governments and monetary authorities. Shortly after the global financial crisis, several EU countries encountered the Euro area sovereign debt crisis, during which troubled banks curtailed their government funding, escalating sovereign borrowing costs. The pathway to overcoming these crises involved substantial restructuring and consolidation within the EU banking sector, raising questions about the sustainability of banking institutions' profitability in the context of healthy market competition.

Utilising a substantial panel of 784 relevant banks across all EU member states from 2006 to 2021, this paper empirically examines the contributions of market competition to bank performance and the impacts of various crises on the EU banking sector during this period.

Bank performance is represented by two variables: profitability and capitalisation. Bank profitability is measured using the return on equity ratio, reflecting the bank's management efficiency in generating income from its equity financing. Bank capitalisation is indicated by the equity to total assets ratio, which broadly assesses the bank's financial risk levels.

Two distinct measures are employed to represent bank competition: the Boone indicator, which assesses competition from an efficiency viewpoint, and the Herfindahl-Hirschman Index (HHI), a specific measure of market concentration. Additionally, three dummy variables are included to represent the years of the primary crises: the global subprime financial crisis, the sovereign debt crisis, and the pandemic crisis.

The control variables in this analysis include the cost to income ratio, a key measure of bank efficiency; the net loans to total assets ratio, reflecting the bank's liquidity situation; and the growth of real per capita Gross Domestic Product (GDP), representing the macroeconomic conditions of the country.

To our knowledge, few studies have explored the influence of these explanatory variables on the selected measures of bank performance within a panel of banks from all EU member states. This paper aims to contribute to the existing literature by investigating the relationship between market competiton and bank performance and addressing the following specific questions:

1) Does bank market competition influence bank performance, specifically regarding profitability and capitalisation?

2) Do the results vary depending on the specific proxies utilised to measure bank market competition?

3) How did the various crises impacting the EU banking sector during the review period affect bank stability?

Overall, the findings from both panel fixed (or random) estimations and dynamic twostep Generalized Method of Moments (GMM) estimations clearly indicate that bank market competition has a significant impact on bank performance, particularly concerning profitability. However, the statistical robustness and nature of this influence are contingent upon the specific proxies employed to measure bank market competition, with evidence suggesting that the computed Boone indicators exert a stronger influence than the Herfindahl-Hirschman Index (HHI).

The remainder of the paper is organised as follows. Section 2 reviews pertinent literature. Section 3 outlines the data and methodology employed in the empirical estimations. Section 4 discusses the results obtained. Finally, Section 5 summarises the key conclusions.

2. RELEVANT LITERATURE

The economic literature surrounding the impact of market competition on bank performance is extensive but remains far from reaching a consensus.

The traditional structure-conduct-performance paradigm posits that in highly concentrated markets with lower competition, firms, including banking institutions, tend to achieve higher profits due to tendencies to collude (see, (Berger, Demirgüç-Kunt, Levine, & Haubrich, 2004; Maudos & De Guevara, 2004; Molyneux & Forbes, 1995)). Conversely, the efficient-structure view acknowledges a positive correlation between market concentration and bank profitability, attributing this relationship not to collusion among banks, but to other factors, particularly superior bank efficiency (Demsetz, 1973; Homma, Tsutsui, & Uchida, 2014; Khan, Kutan, Naz, & Qureshi, 2017). In contrast to these perspectives, the quiet-life hypothesis suggests that greater market power leads to diminished efforts by bank managers to maximize returns, indicating a negative relationship between market power and bank profitability (for instance, (Berger & Hannan, 1998; Färe, Grosskopf, Maudos, & Tortosa-Ausina, 2015; Koetter, Kolari, & Spierdijk, 2012).

Several empirical studies have identified potential negative effects of increased competition in the banking sector, aligning with the competition-fragility view, which argues that banks in more competitive environments tend to adopt riskier behaviors. Hellmann, Murdock, and Stiglitz (2000) emphasise the inconsistency between interest-rate liberalisation and prudent bank conduct, suggesting that financial-market liberalisation enhances competition, reduces profits, and exacerbates moral hazard issues. Marquez (2002) highlights the importance of information access, noting that when many banks compete, each becomes less informed and potentially less efficient. Dam and Castillo (2006) conclude that higher competition leads banks to invest in riskier assets, thereby linking high competition levels to increased risks and potential bank fragility. Beck, Demirgüç-Kunt, and Levine (2006) examined the relationship between banking market structure and bank fragility, concluding that crises are less likely to occur in economies with more concentrated banking systems.

Horvath, Seidler, and Weill (2016) analysed the connection between bank competition and liquidity creation, concluding that increased competition reduces liquidity creation. They interpreted this finding as indicative of how competition can heighten bank fragility. Ahnert and Martinez-Miera (2021) assessed how various developments in the banking industry, such as changes in competitive intensity or transparency, impact bank fragility, competitive dynamics, and overall welfare. Their results also support the competition-fragility view, as shocks that heighten competition or transparency lead to increased deposit rates, costly withdrawals, and ultimately, greater bank fragility.

On the other hand, several authors argue that the banking market is not significantly different from other markets, generally supporting the competition-stability view, which asserts that heightened market competition fosters better bank performance. For instance, Boyd and De Nicoló (2005) found that increasing competition in bank markets lowers lending rates and decreases the likelihood of borrower default, which in turn enhances banks' profitability and stability. Similar conclusions are drawn by Boyd, De Nicoló, and Jalal (2009) and De Nicoló and Turk-Ariss (2010), who overall indicate that there is no clear trade-off between market competition and bank stability. Schaeck, Cihak, and Wolfe (2009) also concluded that more competitive banking systems are less susceptible to systemic crises and noted that well-executed economic policies aimed at promoting bank market competition can enhance bank performance and stability. Anginer, Demirguc-Kunt, and Zhu (2014) emphasise that higher competition encourages banks to diversify their risks, rendering banking institutions less fragile in the face of shocks.

Supporting this viewpoint, Goetz (2018) suggests that fewer barriers to entry significantly bolster bank stability in the United States, as increased competition enhances banks' profits and decreases the share of non-performing loans. More recently, Xing, Li, and Feng (2024) empirically assessed the impact of bank market competition on Environment, Social, and Governance (ESG) performance in China from 2010 to 2022. They concluded that increased competition has not only presented new opportunities and challenges for Chinese banks but has also significantly contributed to the improvement of ESG performance among enterprises.

A relevant group of empirical analyses presents mixed results, raising questions about the positive or negative impact of market competition on various aspects of bank performance. For instance, Berger, Klapper, and Turk-Ariss (2009) argue that while market power in the loan market can lead to riskier loan portfolios, the overall risks may remain stable if banks implement suitable risk-mitigating techniques. Their findings align with the competition-stability perspective, indicating that banks with greater market power possess higher loan portfolio risk; however, they also reveal that these banks exhibit lower overall risk exposure, thereby supporting the competition-fragility view.

Martinez-Miera and Repullo (2010) advance the Boyd and De Nicoló (2005) model by incorporating the degree of market competition and emphasising two opposing effects: the risk-shifting effect, which posits that competition reduces the likelihood of bank failure (following De Nicoló's conclusions), and the margin effect, which suggests that increased bank competition lowers the interest payments on non-defaulting loans that serve as a buffer against loan losses. Martinez-Miera and Repullo (2010) conclude that there is generally a U-shaped relationship between competition (measured by the number of banks) and the risk of bank failure. Their research indicates that in highly concentrated markets, the risk-shifting effect prevails because the entry of additional banks diminishes the probability of failure. Conversely, in very competitive markets, the margin effect predominates, as further bank entry raises the risk of failure. Supporting this viewpoint, Claessens (2009) suggests that while competition in financial services is generally beneficial, its effect on bank performance is contingent on the degree of competition, as excessive competition can jeopardize financial stability.

More recently, Brei, Jacolin, and Noah (2020) identified U-shaped relationships in their analysis using data from 33 Sub-Saharan African countries from 2000 to 2015. They concluded that up to a certain threshold, higher bank competition correlates with lower credit risks, but beyond that point, increased competition leads to higher credit

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risks. Their findings imply that enhanced competition should be accompanied by policies aimed specifically at maintaining financial stability, recommending that policymakers promote bank competition in relatively concentrated banking sectors, but only to a certain extent.

Similarly, Cuestas, Lucotte, and Reigl (2020) confirmed the existence of a U-shaped relationship between competition and financial stability in a study of commercial banks in the Baltic countries from 2000 to 2014. This research underscores the significance of how the banking industry's structure evolves for financial stability, suggesting that policymakers should endorse mergers and acquisitions during periods of intense competition, while inhibiting further concentration in already highly concentrated banking markets.

Heterogeneous results were also observed in the work of Tabak, Fazio, and Cajueiro (2012) which analysed the effects of bank competition on risk-taking across ten Latin American countries from 2003 to 2008. They concluded that competition influences risk-taking behaviour in a non-linear manner, where both high and low levels of competition enhance financial stability, while the opposite is true for average levels of competition. Furthermore, this study highlights the importance of bank size and capitalisation, indicating that banks in competitive markets appear less vulnerable, particularly larger banks, as those with higher capital ratios tend to be more stable.

Liu and Wilson (2013) examine the relationship between competition and stability, concluding that the impact is contingent upon the initial risk levels of the banks in question. Specifically, they find that banks with higher risks tend to adopt a more cautious approach to risk in response to increased competition, safeguarding their franchise value. Conversely, competition appears to positively influence the risk profile of banks with lower initial risk levels. Soedarmono, Machrouh, and Tarazi (2013) investigate the effects of competition on stability, focusing on several emerging Asian markets and accounting for crisis periods from 1994 to 2009. Their findings support the competition-fragility view, indicating that greater market power in the banking sector correlates with higher capital ratios, increased income volatility, and elevated insolvency risks for banks. Nevertheless, they also observe that market power exerted a stabilising influence during crises, particularly during the 1997 Asian crisis. Furthermore, the outcomes of their analysis are influenced by the size of the largest banks and the "too-big-to-fail" policies in the countries studied.

Schaeck and Cihák (2014) investigate the effect of market competition on bank performance, positing that competition encourages banks to improve cost efficiency, leading to a reallocation of resources from less successful (inefficient) banks to more successful ones. Their findings confirm that competition significantly enhances bank stability by boosting efficiency, while also benefiting bank capital and profitability. However, they note that the effects of competition are heterogeneous and that more fragile banks tend to gain less from competitive environments.

Heterogeneous results are also obtained in studies focusing on the performance of European banks. For instance, De-Ramon, Francis, and Straughan (2018) analysing data from the United Kingdom between 1994 and 2013, found that, on average, the competition-fragility hypothesis holds true, as increased competition generally diminishes bank-level stability. However, the outcomes are not uniform and depend heavily on the financial robustness of the banks involved. Specifically, their research indicates that financially weaker banks may experience benefits from heightened competition, as their profitability and capital levels improve in response to increased competitive pressures, aligning with the competition-stability hypothesis.

Fungáčová, Shamshur, and Weill (2017) analyse the impact of bank competition on credit costs by examining a panel of firms from 20 European countries between 2001 and 2011. Utilising a comprehensive array of bank competition measures, they find that asymmetric information and the heightened difficulty of obtaining information in highly competitive banking markets lead to increased credit costs and elevate bank credit risks. Conversely, Ijtsma, Spierdijk, and Shaffer (2017) empirically investigate the effects of concentration across 25 European Union (EU) countries from 1998 to 2014, considering both bank-level and country-level financial stability. Their findings indicate

that concentration has a minimal impact on stability at both levels, suggesting that neither supervisory restructuring nor typical market-driven mergers are likely to pose significant threats to financial stability in EU countries.

Leroy and Lucotte (2017) undertake an empirical examination of the relationship between competition and bank risk using data from a substantial sample of European listed banks over the period from 2004 to 2013, focusing on both individual and systemic dimensions of risk. The findings indicate that competition typically elevates individual risk, as banks facing competitive pressure are more likely to undertake greater risks. Additionally, an increase in market power is associated with heightened systemic risk, which further contributes to the overall weakening of the financial system.

Guidi (2021) explores the influence of market concentration and market power on financial stability in the banking sector of South-East Europe (SEE) from 2003 to 2012, yielding mixed results. On one hand, a rise in market concentration (measured by the Herfindahl-Hirschman Index) is associated with lower non-performing loan (NPL) ratios, which enhances the financial stability of SEE banks, suggesting that industry concentration promotes greater stability. Conversely, when assessing the Lerner index as a measure of market power, the findings indicate a positive and statistically significant effect on NPL ratios, revealing that increased market power in banks leads to higher NPL ratios.

Herwald, Voigt, and Uhde (2024) examine the effects of banking market concentration, as measured by the Herfindahl–Hirschman Index (HHI), and market power, assessed through product-specific Lerner Indices for both the loan and deposit markets, on bank stability. Their study utilises data from a substantial sample of the European Union (EU-15) spanning from 2013 to 2020. The findings reveal a significant negative impact of market concentration (HHI) on stability, while indicating a noteworthy positive effect of market power (Lerner Indices) on stability.

3. DATA AND METHODOLOGY

This paper utilises data from Moody's Analytics Bank Focus database to analyse two dependent variables that reflect critical aspects of bank performance: profitability and capitalisation. Bank profitability is assessed through the return on equity, specifically the "ROE using P/L before tax, (%)", which illustrates how effectively a bank utilises the capital invested by its shareholders. A higher return on equity indicates greater efficiency in the bank's management in generating income from its equity financing. On the other hand, bank capitalisation is evaluated using the equity to total assets ratio ("Equity/Total assets, (%)"), which shows the proportion of a bank's assets funded by its investors. A higher equity to total assets ratio signifies a lower financial risk, suggesting that the bank is less dependent on debt; conversely, a lower ratio indicates a higher financial risk, reflecting a greater reliance on borrowed capital.

The paper includes two different measures to represent bank competition[1]: the Boone indicator (which measures competition from an efficiency perspective), and the Herfindahl-Hirschman Index (a specific measure of market concentration).

Three Boone indicators are computed: one for the banks' profits ($B_{profits}$), a second one for the banks' loans (B_{loans}) and the third one for the banks' deposits ($B_{deposits}$). As the considered sample includes a different number of banks from each of the 27 EU countries and the banking markets of these countries are not homogeneous, the market share of bank i is related to the sub-sample of the banks of its own country (and not the whole sample of 784 banks), in the year t. The Boone indicators are the values of the coefficients β that are obtained through the estimation of the following linear equations:

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[1] The advantages and disadvantages of using these and other proxies of bank competition (such as the Lerner index) are well-discussed, for example, in Schaeck and Cihák (2014); Leon (2015); Fungáčová et al. (2017); De-Ramon et al. (2018) and Dutta and Saha (2021).

$$B_{loans}:$$
$$ln(Market\ share\ of\ the\ profits)_{i,t} = \alpha + \beta\ ln(Average\ variable\ cost)_{i,t} \quad (1)$$
$$B_{loans}:$$
$$ln(Market\ share\ of\ the\ loans)_{i,t} = \alpha + \beta\ ln(Average\ variable\ cost)_{i,t} \quad (2)$$
$$B_{depositss}:$$
$$ln(Market\ share\ of\ the\ deposits)_{i,t} = \alpha + \beta\ ln(Average\ variable\ cost)_{i,t} \quad (3)$$

Where the average variable cost is proxied by the sum of the interest expense and the non-interest expense to the total profits (in the case of $B_{profits}$), the total loans (for B_{loans}), or the total customer deposits (for $B_{deposits}$).

The Herfindahl-Hirschman Index (HHI) takes into account the market share of each bank relative to the subset of banks within its own country. Consequently, the HHI reflects the degree of market concentration among banks in each of the 27 EU member states. Additionally, it is calculated separately for the market shares of banks' profits, loans, and deposits, following the standard definition:

$$HHI_{profits} = \sum_{i=1}^{N}(Market\ share\ of\ the\ profits)_{i,t}^{2} \quad (4)$$
$$HHI_{loans} = \sum_{i=1}^{N}(Market\ share\ of\ the\ loans)_{i,t}^{2} \quad (5)$$
$$HHI_{deposits} = \sum_{i=1}^{N}(Market\ share\ of\ the\ deposits)_{i,t}^{2} \quad (6)$$

All data regarding the performance of reporting banks is sourced from the Moody's Analytics BankFocus database as of December 2022. The selection of banks considered not only the availability of data for the period from 2006 to 2021 but also the size of the institutions. In general, banks with total assets of less than 2 billion Euros in 2021 were excluded from the sample. However, in EU countries with a limited number of banks possessing substantial total assets, the sample includes those banks with total assets below 2 billion Euros, and not very far from 1 billion Euros in 2021. Annex 1 details the number of banks from each of the 27 EU countries included in the sample, highlighting their representation not only in terms of the percentage of the total banks in the overall sample but also regarding their contributions to total profits, total loans, and total deposits.

The estimations also incorporate three control variables: the "Cost to income ratio (%)", the "Net loans to Total assets ratio (%)", and the natural logarithm of real per capita Gross Domestic Product, represented as "GDP per capita (constant 2015 US$)". As with the other variables related to bank performance, the two financial ratios used as control variables were obtained from the Moody's Analytics BankFocus database. The GDP values were sourced from the World Bank's "Global Financial Development" database, which is freely accessible at the Global Financial Development Database.

The cost to income ratio is a critical indicator of a bank's efficiency; generally, a lower ratio signifies a more efficiently operating bank. The net loans to total assets ratio reflects the bank's liquidity position, indicating the proportion of the bank's assets that are allocated to liquid (or illiquid) loans. A higher ratio indicates decreased liquidity. Additionally, the growth of real GDP per capita serves as a proxy for the macroeconomic conditions of a country.

Furthermore, since the objective of the paper is to evaluate the impact of crises on the performance of banks in EU countries from 2006 to 2021, three dummy variables have been incorporated to account for the key crises during this period: D_1 for the global subprime financial crisis (spanning 2008-2010), D_2 for the sovereign debt crisis (2011-2013), and D_3 for the pandemic crisis (covering 2020 and 2021). The model estimated is as follows:

$$bank\ performace_{i,t} = \alpha_0 + \alpha_1\ bank\ competition_{i,t} + \alpha_2\ cost\ to\ income\ ratio_{i,t} +$$
$$\alpha_3\ net\ loans\ to\ total\ assets\ ratio_{i,t} + \alpha_4\ GDP_{j,t} + \alpha_5\ D_1 + \alpha_6\ D_2 + \alpha_7\ D_3 + \varepsilon_{i,t} \quad (7)$$

Where, the performance of bank i ($i= 1, …784$), in year t ($t = 2006, …, 2021$), is first represented by bank profitability (the return on equity ratio) and then by bank capitalisation (the equity to total assets ratio); bank market competition is measured with one of the mentioned competition indicators: $B_{profits}$, B_{loans}, $B_{deposits}$, $HHI_{profits}$, HHI_{loans}, $HHI_{deposits}$; GDP is the natural logarithm of the real domestic product of the EU country j ($j = 1, …27$); D_1, D_2, and D_3 are the crisis dummies; and e_{it} is the error term.

Annex 2 provides the descriptive statistics and pairwise correlations among the variables included in the estimations.

The stationarity of the examined series is evaluated using several widely recommended panel unit root tests: the Levin-Lin-Chu test (Levin, Lin, & Chu, 2002) and the Fisher-type Augmented Dickey-Fuller (ADF) test (Choi, 2001; Maddala & Wu, 1999) Furthermore, to account for potential structural breaks, the paper presents results from the panel unit root tests proposed by Karavias and Tzavalis (2014) which accommodate breaks in both the intercepts of the individual series and in linear trends.

Annex 3 presents the results obtained, confirming the stationarity of the variables, at least according to one of the performed tests. In most cases, the outcomes of the panel unit root tests align consistently and raise no doubts regarding the stationarity of the series.

Equation 7 is estimated for each of the two dependent variables, which serve as proxies for bank performance (bank profitability and bank capitalisation).

First, fixed and random effects estimations are applied, using the Hausman test values to determine, in each instance, whether the fixed effects model or the random effects model is more suitable. As outlined in Wooldridge (2010) and Greene (2018) fixed effects estimations effectively address a significant concern in cross-sectional studies: the potential exclusion of relevant control variables. Fixed effects regressions control for any time-invariant cross-sectional variables, making them particularly suitable for analyzing the impact of variables that change over time. These models effectively explore the relationship between explanatory variables and the outcome within each cross-sectional unit. In contrast, a random effects model posits that explanatory variables maintain fixed relationships with the response variable across all observations, with these effects potentially varying from one observation to another, typically following a normal distribution. Estimating random effects offers insights into specific levels (similar to fixed effects) while also providing population-level information.

To test the robustness of the results obtained from fixed and random effects, this paper also employs dynamic twostep Generalized Method of Moments (GMM) estimations. GMM is particularly suitable to address concerns related to endogenous regressors. Dynamic GMM panel estimations not only tackle endogeneity issues but also mitigate potential bias in the estimated coefficients. The GMM method, as proposed by Arellano and Bond (1991); Arellano and Bover (1995) and Blundell and Bond (1998) utilises cross-country information and jointly estimates the equations in both first differences and levels.

The validity of the GMM estimations is assessed using the tests suggested by Arellano and Bond (1991) which evaluate autocorrelation—specifically, the assumption that the error term is not serially correlated when examining the differenced error term. By design, first-order autocorrelation, AR(1), is expected to be validated, while second-order, AR(2), and higher-order autocorrelation should not be validated. Additionally, the validity of the instruments is examined using the Sargan-Hansen statistic, which is expected to be robust against heteroskedasticity and autocorrelation.

4. EMPIRICAL RESULTS

The paper presents the findings derived from panel estimations closely following the methodology outlined in the preceding section, with the model represented by Equation 7. Bank performance is initially assessed using the

return on equity ratio, which reflects bank profitability and indicates how efficiently banks are managing shareholders' capital. Subsequently, the analysis utilizes the equity to total assets ratio to measure bank capitalisation and the associated financial risk.

For each of the two dependent variables, six equations are estimated, employing the same set of control variables: the cost to income ratio, the net loans to total assets ratio, and the growth of real per capita GDP. Each equation separately incorporates one of the estimated proxies for bank competition, which include $B_{profits}$, B_{loans}, $B_{deposits}$, $HHI_{profits}$, HHI_{loans}, $HHI_{deposits}$. Additionally, the estimated equations account for three dummy variables representing the major crises that impacted the EU banking sector during the studied period: the global subprime financial crisis ($D1$, covering the years 2008-2010), the sovereign debt crisis (D_2, from 2011 to 2013), and the pandemic crisis (D_3, covering 2020 and 2021).

Table 1 illustrates the outcomes for the two dependent variables, which are the proxies representing bank profitability and bank capitalisation. These results were derived using either fixed or random effects panel estimations, based on the Hausman test values. The values of the F or Wald statistics provide evidence of the robustness of the reported findings.

In general, the results obtained using Boone indicators—measuring competition from an efficiency perspective— are statistically more significant than those derived from HHIs, which measure bank market concentration. Specifically, there is strong statistical evidence that an increase in $B_{profits}$ (the Boone indicator related to banks' profits) positively influences both bank profitability and bank capitalisation. Conversely, an increase in both B_{loans} and $B_{deposits}$ (the Boone indicators pertaining to banks' loans and deposits) does not suggest that competition in traditional bank activities significantly contributes to enhancing bank profitability (as measured by the return on equity ratio) and bank capitalisation (reflected in the equity to total assets ratio).

Furthermore, the influence of market competition, as measured by the Herfindahl-Hirschman Index (HHI), is statistically significant solely regarding bank profitability. More precisely, an increase in bank market concentration, negatively affects bank profitability, which is consistent with the "quiet life" hypothesis. Conversely, there is evidence that increased market concentration in traditional banking activities positively influences bank profitability, although this effect is only statistically significant in relation to banks' deposits.

Additionally, the three control variables have a significant impact on bank performance. Specifically, the growth of real GDP per capita demonstrates a robust positive effect on bank capitalisation and, although less pronounced, also on bank profitability.

The analysis of the impacts of the other two control variables on bank performance reveals, on one hand, that both the cost to income ratio and the net loans to total assets ratio have a significantly negative effect on bank profitability. This indicates that improvements in bank efficiency and liquidity contribute positively to profitability. Conversely, the influence of the cost to income ratio on bank capitalisation is not statistically significant, while the net loans to total assets ratio has a very significant positive impact on bank capitalisation, revealing that less liquid banks are also the less risky ones (i.e. the banks with higher equity to total assets ratios).

Notably, the outcomes related to the three significant crises that impacted the EU banking sector during the analysis period are statistically very significant. They demonstrate a detrimental effect on both bank profitability and capitalisation.

To ensure the robustness of the results obtained from either fixed or random panel estimations represented in Equation 7, we employed dynamic twostep Generalized Method of Moments (GMM) estimations. This approach not only addresses potential endogeneity issues but also mitigates biases in the estimated coefficients.

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Table 1. Results obtained with panel fixed or random effects estimations.

Variables	Bank profitability						Bank capitalisation					
	$B_{profits}$	B_{loans}	$B_{deposits}$	$HHI_{profits}$	HHI_{loans}	$HHI_{deposits}$	$B_{profits}$	B_{loans}	$B_{deposits}$	$HHI_{profits}$	HHI_{loans}	$HHI_{deposits}$
	FE	RE	RE	RE	FE	FE	FE	FE	FE	FE	FE	FE
$B_{profits}$	0.6683** (2.08)						0.2714*** (3.81)					
B_{loans}		-0.2631 (-1.50)						-0.1358*** (-3.13)				
$B_{deposits}$			-0.3967** (-2.34)						-0.1948*** (-4.70)			
$HHI_{profits}$				-0.00004*** (-4.64)						1.69e-06 (0.90)		
HHI_{loans}					0.0008 (1.42)						0.0001 (1.01)	
$HHI_{deposits}$						0.0025*** (3.68)						-0.00005 (-0.30)
Cost to income	-0.0044*** (-3.59)	-0.0047*** (-3.92)	-0.0047*** (-3.94)	-0.0047*** (-3.94)	-0.0044*** (-3.58)	-0.0043*** (-3.54)	0.00003 (0.12)	0.00005 (0.19)	0.00005 (0.17)	0.00004 (0.15)	0.00004 (0.15)	0.00004 (0.16)
Net loans to total assets	-0.0410*** (-2.65)	-0.0307*** (-2.81)	-0.0315*** (-2.89)	-0.0317*** (-2.91)	-0.0418*** (-2.70)	-0.0403*** (-2.60)	0.0253*** (7.35)	0.0248*** (7.21)	0.0243*** (7.05)	0.0250*** (7.27)	0.0250*** (7.27)	0.0250*** (7.26)
GDP per capita	6.733*** (3.10)	0.7504 (1.22)	0.8065 (1.32)	0.5245 (0.87)	6.752*** (3.11)	6.509*** (3.00)	8.066*** (16.73)	8.143*** (16.88)	8.024*** (16.64)	8.118*** (16.82)	8.093*** (16.77)	8.112*** (16.80)
$D1_{(2008-2010)}$	-0.8089** (-2.25)	-1.212*** (-3.61)	-1.235*** (-3.68)	-1.255*** (-3.74)	-0.9267*** (-2.57)	-1.095*** (-3.01)	-0.6713*** (-8.42)	-0.6858*** (-8.62)	-0.7064*** (-8.89)	-0.6922*** (-8.70)	-0.7035*** (-8.78)	-0.6894*** (-8.54)
$D2_{(2011-2013)}$	-2.753*** (-8.07)	-2.971*** (-8.83)	-2.913*** (-8.73)	-2.935*** (-8.80)	-2.748*** (-8.05)	-2.780*** (-8.16)	-0.2251*** (-2.97)	-0.2411*** (-3.16)	-0.2158*** (-2.86)	-0.2065*** (-2.73)	-.2137*** (-2.82)	-0.2067*** (-2.73)
$D3_{(2020-2021)}$	-2.727*** (-6.94)	-2.527*** (-6.48)	-2.612*** (-6.70)	-2.595*** (-6.67)	-2.646*** (-6.65)	-2.471*** (-6.19)	-.2160*** (-2.48)	-0.1975** (-2.26)	-0.2367*** (-2.71)	-0.2180*** (-2.50)	-0.2050** (-2.32)	-0.2238*** (-2.52)
Const	-59.52*** (-2.62)	1.958 (0.30)	1.448 (0.22)	4.666 (0.72)	-61.48*** (-2.71)	-61.85*** (-2.72)	-77.06*** (-15.28)	-78.13*** (-15.49)	-76.83*** (-15.24)	-77.79*** (-15.42)	-77.74*** (-15.41)	-77.64*** (-15.40)
Hausman test (Prob > chi2)	17.16 (0.0164)	8.92 (0.1781)	11.39 (0.0772)	8.56 (0.1279)	14.25 (0.0141)	29.67 (0.0000)	267.95 (0.0000)	271.25 (0.0000)	256.50 (0.0000)	255.63 (0.0000)	248.01 (0.0000)	250.36 (0.0000)
F or Wald test (Prob > F) or (Prob > chi2)	18.88 (0.0000)	127.16 (0.0000)	130.39 (0.0000)	146.62 (0.0000)	18.54 (0.0000)	20.21 (0.0000)	95.89 (0.0000)	95.18 (0.0000)	97.03 (0.0000)	93.82 (0.0000)	93.85 (0.0000)	93.72 (0.0000)

Note: ***significant at 1% level and ** significant at 5% level.

Table 2 displays the results obtained from dynamic twostep GMM estimations. The robustness of these findings is clearly demonstrated by the Wald test values, which indicate first-order autocorrelation, AR(1) without any evidence of second-order autocorrelation, AR(2). The validity of the instruments used is further supported by the results from the Sargan tests.

Consistent with the outcomes from fixed or random effects estimations, there is strong statistical evidence that an increase in competition, as measured by the Boone indicator related to profits, positively affects the return on equity ratio, reflecting bank profitability. Conversely, an increase in competition indicated by the Boone indicators in the loans and deposits markets—representing traditional banking activities—negatively impacts bank profitability. Regarding the other measure of bank market competition, indicating the level of market concentration, the results reveal that a rise in the Herfindahl-Hirschman Index (HHI) associated with profits has negative impact on bank profitability. In contrast, an increase in HHIs calculated for the loans and deposits markets shows a statistically significant positive influence on bank profitability.

Overall, the results confirm the impacts that were observed on the other dependent variable: the equity to total assets ratio, which reflects bank capitalisation. However, the statistical robustness of these results allows for only a confirmation of the positive influence of the Boone indicator related to bank profits and the negative impact of the Boone indicator derived from the loans market.

The findings obtained through GMM estimations regarding the influence of the three control variables on bank profitability and bank capitalisation are generally consistent with those derived from fixed or random effects estimations, albeit not always demonstrating the same level of statistical significance. More specifically, the positive influence of GDP growth has been confirmed, though only concerning the equity to total assets ratio (indicative of bank capitalisation). There is now statistically significant evidence that banks with a higher cost to income ratio are those with greater bank capitalisation. This suggests that more efficient banks (which maintain lower cost to income ratios) might simultaneously be those experiencing higher levels of risk (evidenced by lower equity to total assets ratios).

Moreover, the results concerning the influence of the net loans to total assets ratio confirm the previously found negative impact on bank profitability and the positive impact on bank capitalisation. However, the results obtained from GMM estimations lack statistical robustness.

Additionally, consistent with earlier findings, GMM estimations clearly confirm that in all instances, the three significant crises that affected the EU banking sector during the analysed period had a statistically robust negative impact on both dependent variables (representing bank profitability and bank capitalisation).

Table 2. Results obtained with dynamic twostep system GMM estimations.

Variables	Bank profitability						Bank capitalisation					
	$B_{profits}$	B_{loans}	$B_{deposits}$	$HHI_{profits}$	HHI_{loans}	$HHI_{deposits}$	$B_{profits}$	B_{loans}	$B_{deposits}$	$HHI_{profits}$	HHI_{loans}	$HHI_{deposits}$
Dependent var. $_{t-1}$	0.2812***	0.2817***	0.2831***	0.2838***	0.2820***	0.2792***	0.6018***	0.6047***	0.6046***	0.6042***	0.6039***	0.6022***
	(60.60)	(57.67)	(61.71)	(60.32)	(58.64)	(57.07)	(161.30)	(161.58)	(161.76)	(162.55)	(161.18)	(160.73)
$B_{profits}$	1.233***						.1589***					
	(7.07)						(4.76)					
B_{loans}		−0.4566***						−0.0379**				
		(−3.17)						(−2.09)				
$B_{deposits}$ -			−1.356***						−.0197			
			(−7.86)						(−1.12)			
$HHI_{profits}$				−0.00003***						6.56e-07		
				(−4.89)						(1.12)		
HHI_{loans}					0.0019**						−0.00008	
					(2.43)						(−0.94)	
$HHI_{deposits}$						0.0042***						−0.0001
						(4.56)						(−0.93)
Cost to income	0.0006	0.0005	0.0008	0.0004	0.0006	0.0007	0.0003**	0.0003**	0.0003**	0.0003**	0.0003**	0.0003**
	(0.80)	(0.64)	(1.04)	(0.51)	(0.77)	(0.92)	(1.97)	(2.05)	(2.04)	(2.02)	(2.04)	(1.99)
Net loans to total assets	−0.0079	−0.0094	−0.0172	−0.0105	−0.0114	−0.0052	0.0052	0.0052	0.0044	0.0047	0.0058	0.0050
	(−0.57)	(−0.68)	(−1.29)	(−0.76)	(−0.82)	(−0.37)	(1.36)	(1.33)	(1.14)	(1.22)	(1.50)	(1.29)
GDP per capita	−1.545	−2.495	−2.198	−2.854*	−1.715	−0.8715	0.8703***	0.7168***	0.8187***	0.7732***	0.7815***	0.8306***
	(−0.99)	(−1.61)	(−1.36)	(−1.90)	(−1.13)	(−0.58)	(3.67)	(3.06)	(3.47)	(3.29)	(3.29)	(3.48)
D1$_{(2008-2010)}$	−0.4634***	−0.6905***	−0.7481***	−0.6782***	−0.6565***	−0.6956***	−0.0736***	−0.0940***	−0.0937***	−0.0919***	−0.0919***	−0.0987***
	(−3.16)	(−4.85)	(−5.12)	(−4.78)	(−4.58)	(−4.70)	(−3.05)	(−4.08)	(−4.05)	(−3.99)	(−3.98)	(−4.31)
D2$_{(2011-2013)}$	−1.140***	−1.219***	−1.150***	−1.224***	−1.197***	−1.161***	−0.0428**	−0.0484**	−0.0433**	−0.0418**	−.0418**	−0.0448**
	(−8.04)	(−8.47)	(−7.82)	(−8.67)	(−8.37)	(−8.03)	(−2.08)	(−2.35)	(−2.10)	(−2.02)	(−2.01)	(−2.18)
D3$_{(2020-2021)}$	−1.399***	−1.426***	−1.603***	−1.462***	−1.293***	−1.211***	−0.3905***	−0.3850***	−0.3894***	−0.3873***	−0.3898***	−0.3870***
	(−11.88)	(−12.46)	(−13.52)	(−12.82)	(−9.98)	(−10.20)	(−12.66)	(−12.37)	(−12.51)	(−12.44)	(−12.28)	(−12.30)
Const	22.65	31.64**	28.79*	35.80**	20.89	7.987	−6.058**	−4.620*	−5.629**	−5.158**	−5.182**	−5.607**
	(1.38)	(1.92)	(1.68)	(2.25)	(1.29)	(0.50)	(−2.42)	(−1.86)	(−2.25)	(−2.07)	(−2.04)	(−2.19)
Wald chi2(8) test	4679.02	4510.95	4706.73	4548.34	4249.47	3946.07	28777.25	28282.86	28419.91	28663.21	28766.54	28090.97
(Prob > chi2)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AB AR(1) z	−3.1214	−3.1335	−3.1353	−3.1377	−3.1382	−3.1465	−3.0626	−3.069	−3.0685	−3.0667	−3.0696	−3.0667
(Pr > z)	(0.0018)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0022)	(0.0021)	(0.0022)	(0.0022)	(0.0021)	(0.0022)
AB AR(2) z	−0.06796	−0.00939	.0299	0.03204	−0.02347	−0.02963	1.9007	1.8888	1.8859	1.8835	1.8859	1.8844
(Pr > z)	(0.9458)	(0.9925)	(0.9761)	(0.9744)	(0.9813)	(0.9764)	(0.0573)	(0.0589)	(0.0593)	(0.0596)	(0.0593)	(0.0595)
Sargan test chi2	264.3037	266.6727	265.7331	271.2026	266.603	262.0233	292.1389	294.6513	296.7694	297.6146	294.1126	295.3661
(Prob > chi2)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: ***significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 3. Summary of the results obtained for bank profitability.

Variables	$B_{profitss}$		B_{loans}		$B_{deposits}$		$HHI_{profits}$		HHI_{loans}		$HHI_{deposits}$	
	FE	GMM	RE	GMM	RE	GMM	RE	GMM	FE	GMM	FE	GMM
$B_{profits}$	+**	+***										
B_{loans}			−	-***								
$B_{deposits}$					-**	-***						
$HHI_{profits}$							-***	-***				
HHI_{loans}									+	+**		
$HHI_{deposits}$											+***	+***
$D1_{(2008-2010)}$	-**	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***
$D2_{(2011-2013)}$	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***
$D3_{(2020-2021)}$	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***

Note: ***significant at 1% level and ** significant at 5% level. Information presented in Table 1 and Table 2

Table 3 summarises the findings related to the effects of computed bank market competition and the three crises on the return on equity ratio, which serves as an indicator of bank profitability. Across all scenarios, the results derived from both panel fixed (or random) estimations and dynamic GMM estimations align closely. Importantly, there is strong evidence that the significant crises impacting the EU banking sector during the analysed period had a substantial negative influence on bank profitability.

The reported impacts of the computed measures of bank market competition highlight the distinct characteristics of these measures. The Boone indicators assess competition from an efficiency standpoint, and results pertaining to traditional banking activities (i.e., loans and deposits) indicate that an increase in bank market competition, as measured by B_{loans} and $B_{deposits}$, adversely affects bank profitability. In a highly competitive market, banks often need to compete for clients, which may compel them to reduce their margins and ultimately lower their return on equity.

Conversely, the competition measure linked to bank profits, $B_{profits}$, shows a consistent positive relationship with the return on equity ratio, indicating that an increase in competition in bank profits positively influences bank profitability. Moreover, the findings suggest that the profitability of the EU banking sector is not significantly tied to the traditional intermediation roles that banks play in providing loans and collecting deposits. Probably banks tend to perform more efficiently and profitably in non-traditional activities, particularly those related to various off-balance-sheet operations.

Table 4. Summary of the results obtained for bank capitalisation.

	$B_{profitss}$		B_{loans}		$B_{deposits}$		$HHI_{profits}$		HHI_{loans}		$HHI_{deposits}$	
	FE	GMM	FE	GMM	FE	GMM	FE	GMM	FE	GMM	FE	GMM
$B_{profits}$	+***	+***										
B_{loans}			-***	-**								
$B_{deposits}$					-***	−						
$HHI_{profits}$							+	+				
HHI_{loans}									+	−		
$HHI_{deposits}$											−	−
$D1_{(2008-2010)}$	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***	-***
$D2_{(2011-2013)}$	-***	-**	-***	-**	-***	-**	-***	-**	-***	-**	-***	-**
$D3_{(2020-2021)}$	-***	-***	-**	-***	-***	-***	-***	-***	-**	-***	-***	-***

Note: ***significant at 1% level and ** significant at 5% level. Information presented in Table 1 and Table 2.

Additionally, the other three computed proxies for bank competition, specifically the Herfindahl-Hirschman Indices (HHIs), which indicate market concentration. The results demonstrate that a higher concentration of banks' profits, as measured by $HHI_{profits}$, does not enhance bank profitability. This finding supports the "quiet life hypothesis," which posits that increased market power concentration is generally linked to poorer performance. In contrast, the concentration associated with traditional banking activities, reflected in HHI_{loans} and $HHI_{deposits}$,

positively impacts bank profitability, although this relationship does not exhibit the same level of statistical robustness. These results underscore the ability of banks operating in highly concentrated markets to influence interest rates, thereby increasing their margins and return on equity ratios.

Table 4 summarises the results obtained with panel fixed (or random effects) and dynamic GMM estimations, with bank capitalisation represented by the capital ratio of equity to total assets as the dependent variable. Overall, the findings presented in this table align closely with those in Table 3, clearly demonstrating similar impacts on bank performance—both in terms of profitability and capitalisation—associated with the examined bank crises and market competition, as indicated by the computed Boone indicators ($B_{profits}$, B_{loans}, $B_{deposits}$).

However, the results concerning the impacts of other computed proxies for bank market competition ($HHI_{profits}$, HHI_{loans}, $HHI_{deposits}$) lack statistical robustness, suggesting that bank market concentration is not significantly influential on bank capitalisation.

5. CONCLUSIONS

This paper contributes to the literature examining the relationship between bank market competition and the performance of the EU banking sector. It utilises a substantial panel of 784 banks from all EU member states over the period 2006-2021. The study considers two key aspects of bank performance: profitability, measured by the return on equity ratio, and capitalisation, represented by the equity to total assets ratio. Bank market competition is represented using two estimated measures: the Boone indicator, which assesses competition from an efficiency perspective, and the Herfindahl-Hirschman Index (HHI), a specific measure of market concentration. These measures are computed separately for the banks' profits, loans, and deposits.

To analyse the effects of the crises on bank performance during the 2006-2021 period, the estimations include three dummy variables corresponding to the years of the major crises: the global subprime financial crisis (2008-2010), the sovereign debt crisis (2011-2013), and the pandemic crisis (2020 and 2021).

Additionally, three control variables are incorporated into the estimations: the cost to income ratio (which represents bank efficiency), the net loans to total equity ratio (indicating the bank's liquidity situation), and the growth of real GDP per capita (serving as a proxy for macroeconomic conditions).

The findings derived from panel fixed and random effects estimations, along with dynamic twostep system GMM estimations, lead to the following conclusions:

1) There is substantial evidence that competition in the banking market significantly influences the performance of the EU banking sector. This impact is more pronounced on bank profitability—specifically reflected in the return on equity ratio, which measures the effectiveness of bank management in generating income from equity financing—than on bank capitalisation, evaluated through the equity to total assets ratio, indicating the level of financial risk faced by the banks. While the results are not entirely unanimous, they do suggest the following conclusions:

- The results related to the competition measures computed in the loans market are fully in line with those computed in the deposits market, revealing that there are no significant differences regarding the influence of market competition (concerning traditional banking activities) on bank performance.

- However, the results associated with the competition measures computed for banks' profits are not fully in line with those related to the loans and deposits markets revealing that banks' profits are not evidently associated with banks' traditional activities.

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2) The results obtained are influenced by the specific proxies employed to measure bank market competition, leading to the following conclusions:

- The effects of competition measures on the two proxies for bank performance reveal distinct characteristics inherent to each measure. Overall, the findings demonstrate greater statistical robustness when competition is represented by Boone indicators (which assess competition from an efficiency perspective) compared to the situations when it is measured using the Herfindahl-Hirschman Index (HHI), which gauges market concentration in banking.

- There is obust evidence that in all scenarios Boone indicators associated with profits exert a positive influence on both bank profitability and capitalisation. Conversely, Boone indicators calculated for the loans and deposits markets have negative impacts on the two proxies of bank performance.

- Different results emerge regarding banks' profitability when competition is assessed using the Herfindahl-Hirschman Indices (HHIs). Specifically, the concentration of banks' profits appears to have a negative effect on profitability, whereas the findings suggest that an increase in market concentration linked to traditional banking activities may positively influence bank profitability. These results indicate that heightened market concentration can be associated with reduced competition from an efficiency standpoint.

- Conversely, the findings concerning the impact of the three calculated HHIs—specifically related to banks' profits, loans, and deposits—on bank capitalisation are not statistically significant. This result suggests that market concentration within the EU banking sector is not particularly relevant to its capitalisation.

3) There is substantial evidence indicating that the three significant crises impacting EU banks during the analysed period adversely affected both bank profitability and capitalisation.

The results related to the control variables are not entirely conclusive; however, they do suggest a negative effect of bank inefficiency—indicated by an increased cost to income ratio—on bank profitability, particularly when employing fixed or random panel estimations. Conversely, the positive relationship between the cost to income ratio and bank capitalisation suggests that more efficient banks tend to assume greater risks.

Additionally, there is evidence that an increase in the net loans to total assets ratio, which measures bank liquidity, negatively influences bank profitability while positively affecting bank capitalisation. This implies that banks with lower liquidity may be the more profitable and less risky entities.

The results obtained from both panel fixed or random effects estimations and GMM estimations clearly demonstrate that macroeconomic conditions significantly influence bank performance. Specifically, there is statistically significant evidence that an increase in real per capita GDP positively impacts bank profitability and capitalisation.

Overall, the findings of this paper offer valuable insights for bank managers and policymakers tasked with fostering effective competition in banking markets.

The results indicate that banks' profits are not strongly linked to the traditional banking activities. While bank market competition, assessed from an efficiency perspective using Boone indicators, appears to positively influence both profitability and capitalisation, these indicators related to bank loans and deposits have a negative effect on performance. The findings also reveal that an increase in market concentration, as measured by Herfindahl-Hirschman Index (HHI) scores, is not particularly relevant for explaining the capitalisation of the EU banking sector.

Additionally, the results underscore the importance of macroeconomic conditions, particularly the beneficial impact of real per capita GDP growth on both bank profitability and capitalisation. The paper reaffirms the crucial

role of political and regulatory authorities, not only in ensuring that bank market competition does not exacerbate crisis risks but also in promoting economic growth.

Further research should be encouraged in this field, namely studies exploring the impact of the different national and EU policies as well as significant exogenous shocks, on banking systems, especially in light of the challenges that the global and EU member states are currently facing during these turbulent years.

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Annexes

Annex 1. Number of banks by Eu member-state and their representativeness.

EU country	Number of banks	% of the total banks	% of the profits in 2021	% of the provided loans in 2021	% of the deposits in 2021
Austria	27	3.44	3.10	2.44	2.62
Belgium	19	2.42	4.62	3.37	3.66
Bulgaria	9	1.15	0.31	0.14	0.20
Croatia	4	0.51	0.29	0.14	0.21
Cyprus	5	0.64	0.85	0.30	0.42
Czech Rep.	12	1.53	1.34	0.70	0.96
Denmark	15	1.91	1.85	1.85	1.17
Estonia	4	0.51	0.16	0.08	0.09
Finland	7	0.89	2.71	1.81	1.39
France	129	16.45	37.69	32.97	31.05
Germany	322	41.07	16.55	26.30	26.82
Greece	6	0.77	-2.11	0.50	0.76
Hungary	6	0.77	0.82	0.29	0.44
Ireland	6	0.77	1.14	0.82	1.23
Italy	63	8.04	9.10	9.68	9.66
Latvia	5	0.64	0.10	0.05	0.08
Lithuania	4	0.51	0.14	0.07	0.13
Luxembourg	34	4.34	1.28	0.94	1.33
Malta	7	0.89	0.06	0.07	0.12
Netherlands	16	2.04	6.34	7.28	6.68

EU country	Number of banks	% of the total banks	% of the profits in 2021	% of the provided loans in 2021	% of the deposits in 2021
Poland	18	2.30	1.33	1.16	1.47
Portugal	12	1.53	0.98	0.94	1.27
Romania	6	0.77	0.56	0.19	0.30
Slovakia	5	0.64	0.21	0.20	0.19
Slovenia	7	0.89	0.22	0.11	0.17
Spain	28	3.57	6.81	4.74	5.55
Sweden	8	1.02	3.55	2.84	2.05

Annex 1 reports the number of the banks of each EU country that were considered in the estimations of this paper, their representativeness in terms of the whole panel of EU banks as well as their representativeness in terms of the obtained profits, and the provided loans and deposits of the considered banks in 2021. The data used in the paper related to banks and their performance were sourced from the Moody's Analytics BankFocus database in December 2022.

Annex 2. Descriptive statistics and correlation matrices.

Descriptive statistics

Variables	Mean	Std. dev.	Min	Max
Return on equity	6.786	15.533	-615.11	112.64
Equity to total assets	8.501	5.062	-30.52	84.47
$B_{profits}$	-0.751	0.547	-4.47	1.55
B_{loans}	-0.707	0.983	-10.67	6.18
$B_{deposits}$	-0.414	0.975	-9.56	7.47
$HHI_{profits}$	2175.3	15075.9	27.04	688349.1
HHI_{loans}	1614.9	1146.4	31.55	7248.81
$HHI_{deposits}$	1639.2	1018.4	9.93	6611.28
Cost to income	67.360	106.7	-10280.9	2429.97
Net loans to total assets	58.573	19.83	0	221.62
GDP per capita	10.473	0.448	8.64	11.63

Correlation matrices

	Return on equity	$B_{profits}$	B_{loans}	$B_{deposits}$	$HHI_{profits}$	HHI_{loans}	$HHI_{deposits}$	Cost to income	Net loans to total assets	GDP per capita
Return on equity	1.000									
$B_{profits}$	0.014	1.000								
B_{loans}	-0.013	0.284	1.000							
$B_{deposits}$	-0.004	0.226	0.318	1.000						
$HHI_{profits}$	-0.042	-0.039	0.029	0.006	1.000					
HHI_{loans}	-0.034	-0.294	-0.394	-0.028	0.103	1.000				
$HHI_{deposits}$	-0.039	-0.311	-0.345	-0.056	0.108	0.969	1.000			
Cost to income	-0.046	0.0264	0.033	0.018	0.001	-0.018	-0.022	1.0000		
Net loans to total assets	-0.036	0.029	0.065	0.009	-0.013	-0.055	-0.025	-0.006	1.000	
GDP per capita	0.011	0.412	0.222	0.239	-0.064	-0.175	-0.219	0.024	-0.119	1.000
	Equity to total equity	$B_{profits}$	B_{loans}	$B_{deposits}$	$HHI_{profits}$	HHI_{loans}	$HHI_{deposits}$	Cost to income	Net loans to total assets	GDP per capita
Equity to total assets	1.000									
$B_{profits}$	-0.031	1.000								
B_{loans}	-0.106	0.284	1.000							
$B_{deposits}$	-0.114	0.226	0.318	1.000						
$HHI_{profits}$	0.001	-0.039	0.029	0.006	1.000					

HHI$_{loans}$	0.066	-0.294	-0.394	-0.028	0.103	1.000			
HHI$_{deposits}$	0.063	-0.311	-0.345	-0.056	0.108	0.969	1.0000		
Cost to income	0.014	0.026	0.033	0.018	0.001	-0.018	-0.022	1.000	
Net loans to total assets	0.073	0.029	0.065	0.009	-0.013	-0.055	-0.025	-0.006	1.000
GDP per capita	-0.087	0.412	0.222	0.239	-0.064	-0.175	-0.219	0.024	-0.119	1.000

Annex 2 presents the descriptive statistics and correlations between the variables in the empirical estimations aimed at analysing the impact of bank market competition on the performance of the EU banking sector. It provides statistics for the dependent variables, including return on average equity and the equity to total assets ratio, alongside the computed measures of bank competition: the Boone indicators (B$_{profits}$, B$_{loans}$, B$_{deposits}$) and Herfindahl-Hirschman Indices (HHI$_{profits}$, HHI$_{loans}$, HHI$_{deposits}$). Additionally, it includes three control variables: the cost to income ratio, the ratio of net loans to total assets, and the natural logarithm of real per capita GDP. The data utilised in this paper regarding banks and their performance were sourced from the Moody's Analytics BankFocus database as of December 2022, while the values for real GDP per capita were obtained from the World Bank database "Global Financial Development" in November 2022.

Annex 3. Results obtained with panel unit root tests (p-values).

Variables	Levin Li	Fisher[(*)]	Karavias and Tzavalis[(**)]
Return on equity	0.000	0.000	0.000
Equity to total assets	0.000	0.000	0.000
B$_{profits}$	0.000	0.000	0.000
B$_{loans}$	0.000	0.000	0.000
B$_{deposits}$ -	0.000	0.000	0.000
HHI$_{profits}$	0.000	0.000	0.000
HHI$_{loans}$	0.000	0.122	0.000
HHI$_{deposits}$	0.000	0.000	0.000
Cost to income	0.000	0.000	0.000
Net loans to total assets	0.000	0.000	0.000
GDP per capita	0.000	0.811	0.000

Annex 3 presents the p-values obtained from three panel unit roots tests Levin-Lin-Chu (Levin et al., 2002) the Fisher-type (ADF) test (Choi, 2001; Maddala & Wu, 1999) and Karavias and Tzavalis (2014) tests for the dependent variables: the return on equity and the equity to total assets ratio, as well as the computed measures of bank competition Boone indicators (B$_{profits}$, B$_{loans}$, B$_{deposits}$,) and Herfindahl-Hirschman Indices (HHI$_{profits}$, HHI$_{loans}$, HHI$_{deposits}$) and the three control variables: the cost to income ratio, the ratio of the net loans to total assets, and the natural logarithm of the real per capita GDP. The data pertaining to banks and their performance were sourced from the Moody's Analytics BankFocus database as of December 2022, while the values for real GDP per capita were obtained from the World Bank database "Global Financial Development" in November 2022.