U.PORTO

MASTER'S DEGREE
FINANCE

THE IMPACT OF THE COVID-19 PANDEMIC ON EUROPEAN BANKS' PERFORMANCE

Fábio Augusto Monteiro Gomes

M

2023

U.PORTO
FEP FACULDADE DE ECONOMIA
UNIVERSIDADE DO PORTO

THE IMPACT OF THE COVID-19 PANDEMIC ON EUROPEAN BANKS' PERFORMANCE

Fábio Augusto Monteiro Gomes

Dissertation
Master in Finance

Supervised by
Carlos Francisco Ferreira Alves, PhD

2023

Bibliographic note

Fábio Gomes was born on the 30th of April of 2000, in São Vicente Island, Cape Verde.

In 2016, he enrolled in Professional Technical Course in Accounting and Administration at *Escola Comercial e Industrial do Mindelo – Guilherme Dias Chantre.* Two years later, in 2018, he moved to Portugal, where he started the Bachelor degree in Business Administration at the School of Economics and Management (FEP), University of Porto. In 2021, he completed the bachelor's degree and began the Master's degree in finance, also at FEP.

The conclusion of this dissertation will mark the accomplishment of the Master's in Finance.

Abstract

The unpredictable Covid-19 pandemic that emerged in Europe in early 2020 tanked the economy, as countries went to lockdowns and direct contact between people was reduced to the bare essentials. The negative impacts were extended to banks and other financial firms due to the sector's interdependence, although they could deliver services remotely and did not require direct client interaction.

This dissertation aims contribute to the literature. Particularly, its primary goal is to comprehend the impact of the pandemic in the European commercial banks on their performance. Additionally, perform a comparative analysis between banks under Internal Ratings-Based approach and those under Standard Approach. These approaches were introduced by the Basel II accord in 2004.

The sample consists of 397 commercial banks from 30 European countries with an average of 72 banks that apply Internal Ratings-Based approach and 325 under Standard approach. The period in analyze runs from 2017 to 2021. The analysis is based on the Difference-in-Differences methodology.

The study shows that the differences between IRB bank and SA bank's ROA and ROE from 2017 to 2020 (pre-pandemic period) is not statistically significant. Also, banks under SA approach had superior performance during that period regarding the NIM.

In terms of the pandemic's negative impact on banks using the SA approach, the effect is only statistically significant for ROE and NIM, but it is not statistically significant for ROA.

Moreover, the IRB strategy spared banks from further losses when compared to the SA approach when examining the NIM. This result is only observable when bank-level variables, macroeconomic-level variables, or country fixed-effects are adjusted for. For ROA and ROE, the results are not statistically significant.

Key-words: Bank Performance, Internal Ratings-Based Approach, Standard Approach, Covid-19 Pandemic, Difference-in-Differences (Diff-in-Diff)

Resumo

A imprevisível pandemia da Covid-19 que erguer-se na Europa no início de 2020 abalou a economia, à medida que os países entravam em confinamento e o contato direto entre as pessoas foi reduzido ao essencial. Os impactos negativos estenderam-se aos bancos e às outras empresas financeiras devido a interdependência do setor, embora pudessem prestar serviços à distância e não exigissem interação direta com os clientes.

Com esta dissertação pretende-se compreender o impacto da pandemia nos bancos comerciais europeus no seu desempenho. Adicionalmente, realizar uma análise comparativa entre os bancos sujeitos ao método *IRB* e os bancos sujeitos ao método *Standard*. Estas metodologias foram introduzidas pelo Acordo de Basileia II em 2004.

A amostra é constituída por 397 bancos comerciais de 30 países europeus, com uma média de 72 bancos que aplicam a abordagem *IRB* e 325 sob a abordagem *Standard*. O período em análise vai de 2017 a 2021. A análise baseia-se na Metodologia Diferença-em-Diferenças.

O estudo concluiu que o as diferenças entre o *ROA* e o *ROE* dos bancos sob a abordagem SA entre 2017 e 2020 (período pré-pandemia) não são estatisticamente significativas. Além disso, os bancos abrangidos pela abordagem SA tiveram desempenho superior durante esse período em relação ao *NIM*.

Em termos do impacto negativo da pandemia nos bancos que utilizam a abordagem SA, o efeito é apenas estatisticamente significativo para o *ROE* e o *NIM*, mas não é para o *ROA*.

Além disso, a metodologia *IRB* poupou os bancos de mais perdas comparativamente aos bancos com a abordagem SA em relação ao NIM. Este resultado só é observável quando as variáveis a nível bancário, a nível macroeconómico ou os efeitos fixos por país são ajustados. Em relação ao *ROA* e ao *ROE*, os resultados não são estatisticamente significativos.

Palavras-chave: Desempenho Bancário, Abordagem Baseada em Ratings Internos, Abordagem Padrão, Pandemia de Covid-19, Diferença-em-Diferenças (Diff-in-Diff)

Content Index

Table Index

Figure Index

Acronyms

BCBS: Basel Committee on Bank Supervision

Diff-in-Diff: Difference-in-Difference

EAD: Exposure at default

EBA: European Banking Authority

ECB: European Central Bank

IRB: Internal Ratings-Based approach

LGD: Loss given default

NIM: Net Interest Margin

PD: Probability of default

ROA: Return on Assets

ROE: Return on Equity

RWA: Risk-Weighted Asset

SA: Standard approach

1. Introduction

The lockdown to prevent the spread of the Covid-19 has halted economic activity across numerous sectors, with important implications for companies and households. Direct customer contact-based businesses lost sources of income, and households with workers in these industries lost employment income. Although banks could provide services remotely and did not rely on direct client contact, the Covid-19 crisis' detrimental effects were extended to banks and other financial institutions due to the sector's connection to the other ones. This occurs because banks operate as a provider of payment, savings, credit, and risk management services.

One of the immediate effects of the health emergency, and a relevant feature to this work is the increased credit risk of banks. In order to continue financing the economy as a whole and promote its recovery, banks were asked to differentiate between essentially transient events that would be quickly absorbed, and longer-term repercussions that would necessitate management and reclassification activities. (KPMG, 2020).

Moreover, businesses that ceased operations lost out on income, and families whose members had lost their employment or been layoff had lower incomes which hindered the payment of their debts. Banks were also negatively affected as bonds and other traded financial instruments have lost value as well as faced lower non-interest revenues, as there was lower demand for their different services (Beck, 2020). Lastly, there was a rising demand for credit from businesses, who needed more cash flow to cover expenses even in times of no or reduced earnings. At the same time, the banking sector had the role of supporting firms and households during that period of lower revenues and incomes, which had triggered important policy actions by financial supervisors and governments (Beck, 2020).

As a result, global capital markets had seen severe instability and high volatility due to the COVID-19. Bank's valuations had shrunk in all around the world, making the financial industry one of the most affected. During COVID-19, banking stocks were hit. The majority of banks had a price decline in the middle of March between January 1st, 2020, and April 30th, 2020. The Euro STOXX banks index suffered a significant decrease of 40.18 percent during the specified time, which had a negative influence on European banks (KPMG, 2020).

As said by Claudio Borio, Head of the Monetary and Economic Department (June 2020), this crisis did not result from unravelling previous financial imbalances, been truly exogenous. And policymaker should see banks as part of the solution once the shock found them in a strong financial position.

In 1974, the Group of Ten (G-10) [1] central banks established the Banking Supervision Committee to ensure the health of the banking industry and to ease international transactions. Perhaps the most meaningful accomplishment was the introduction of the Internal Ratings-Based (IRB) approach introduced by the Second Accord of the Basel Committee on Banking Supervision (Basel II) as an alternative to the Standardized (SA) approach. The SA technique requires banks to employ risk weights issued by regulators, whereas the IRB approach requires banks to estimate the various components of the projected loss using their own internal rating models (Cucinelli et al., 2018). Such improvement was insufficient to avert the 2007-2008 global financial crisis, prompting the implementation of Basel III in 2011. The third agreement aimed to increase liquidity and leverage in order to tighten capital needs.

Considering this, the purpose of this research is to execute an analysis of the performance of European Banks (commercial banks) through the pandemic. Additionally, perform a comparative evaluation between banks stuck to internal rating-based models and those in standardized approach when scrutinizing credit risk through the difference-in-difference method.

This dissertation is structured into six chapters. Chapter one contains the introduction. Chapter 2 presents the literature review. Chapter 3 explains the research hypothesis. Chapter 4 covers the data sample, the variables description and the methodology used. Chapter 5 presents the regression results and the robustness tests. Lastly, chapter 6 highlights the main conclusions and limitations.

[1] Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom and the United Stated

2. Literature Review

2.1. Bank's Performance

Kaplan and Norton (1992) described performance measurement as a way to review an organization's financial and nonfinancial goals. Financial ratios are often used to evaluate the financial trustworthiness of a bank and the quality of its administration (Wirnkar & Tanko, 2008). Lebas (1995), by his turn, defined performance measurement as a system by which a company monitors its daily operations and evaluates if it is attaining its objectives.

As reported by Wirnkar & Tanko, 2008, Beaver (1966) was the first person to use financial ratios to predict bankruptcy. However, his study was considered limited as he only considered one ratio at a time. Two years later, Altman (1968) changed this approach by bringing to bear a multiple discriminant analysis where information from various financial ratios were combined in single model, resulting in the Altman's z- score model. Although this model gained popularity as it was simple to use and precise, Altman considered businesses from distinct sectors as same. Therefore, the scrutiny of different values for a healthy indication by the financial ratios of the different sorts of businesses were ignored.

According to Wu (2012), traditional performance evaluations depend on simple and consistent financial data, being return on earnings (ROE) and return on assets (ROA). Nonetheless, Hanley and Sutter (1997) affirmed they may not emphasize the strategies that led to top performance. In the same line of thought, Bhagwat and Sharma (2007) explained that using only ROA or ROE does not necessarily indicate which businesses are the most profitable, and it does not determine which one offers the greatest returns to the investors. Thus, Wu (2012) suggested that performance evaluation should be combined with the global strategy of the business and involve comprehensive criteria (i.e., both financial and nonfinancial indicators).

Despite the limitation of the financial ratios appointment above, many studies that followed early work by Short (1979) and Bourke (1989) on performance of banks and its determinants has considered financial ratios in their research.

Bank profitability is determined using internal and external drivers. Bank-specific characteristics are among the internal determinants. External variables are environmental variables that are predicted to have an impact on financial institution profitability (Dietrich & Wanzenried, 2011).

Most studies examine internal drivers of banking profitability such as bank size, risk, capital ratio, and operational efficiency. Pasiouras and Kosmidou (2007) found a positive and meaningful relationship between the size and the profitability of a bank due to a higher degree of product, loan diversification and benefits from economies of scale. On the other hand, Berger et al. (1987), provided evidence that costs are slightly reduced as the size of a bank increases and that exceptionally large banks often face scale inefficiencies. Micco et al. (2007) for instance, find no correlation between the bank's size and the ROAA (return on average assets). Adam (2014) also stated that bank size (natural logarithm of total assets) has no significant impact on both banks profitability measures (ROA and ROE).

Pasiouras and Kosmidou (2007) also concluded that the best performing banks are those who maintain a high level of equity relative to their assets as they tend to face lower costs of funding due to lower eventual bankruptcy costs.

In addition, utilizing the financial ratios of the banking data, Kosmidou et al. (2006) found that small banks show better performance than large banks after analyzing performance factors such as noninterest expenses/average assets, loan loss provisions/net interest, interbank ratio, equity/ total assets, and equity/net loans.

Nikolić et al. (2022) stated that the size of the board of directors, the number of independent board members and number of women in the board of directors does not have a statistically significant effect on either ROA or ROE after analyzing 22 Serbian banks from 2015 to 2019.

Dietrich & Wanzenried, (2011) defended that bank profitability is explained by operational efficiency, the growth of total loans, funding costs and the business model. The efficiency and the loan volume growth affect banks profitability positively, whereas high funding costs lead to lower profitability. Profitability is also affected by the interest income

share. Banks that rely mainly on interest income are less lucrative than banks with a more diversified income.

Wirnkar & Tanko (2008) concluded in their bank's performance evaluation study that each factor in CAMEL model was incapable to capture the wholistic performance of a bank. Moreover, due to the relative weight of importance of the factors, a switch in the acronym from CAMEL to CLEAM was suggested.

2.2. The Basel Committee

The Basel Committee on Bank Supervision (BCBS), originally called the Committee on Banking Regulations and Supervisory Practices, was founded in the end of 1974 by the central bank of the Group of Ten (G-10) countries. Nowadays, it consists of 45 members from 28 jurisdictions, involving central banks and authorities with recognized obligation for the regulation of banking business. The Committee has produced a number of international standards for bank regulation, most notably the major releases of the capital adequacy accords known as Basel I, Basel II, and Basel III. (BIS, 2023)

Basel I

In 1988, the Basel I regulation accord introduced risk based capital charges. That is, dissimilar categories of bank's assets were allocated to different classes with preassigned risk-weights (BCBS, 1988). Capital requirements were defined in terms of risk-weighted assets (RWAs). Under this accord, a bank was considered 'sufficiently capitalized' if its regulatory capital was 8% (or more) of its RWAs. RWAs were calculated by multiplying certain risk-weights with corresponding asset amounts. According to Montes et al. (2018), such system was built on a crude measure of risk that did not reflect the variation in risk across different assets inside one of its categories.

Basel II

In 2004, a revised version of the 1988 Accord was released – Basel II. Its primary objective was to strengthen the international banking system's stability relating to a risk management improvement through regulatory capital requirements more in line with bank good practices. The new Accord was comprised in three pillars (BIS, 2023):

1. Minimum capital requirements, which sought to develop and expand the standardized rules set out in the 1988 Accord;

2. Supervisory review of an institution's capital adequacy and internal assessment process;

3. Effective use of disclosure as a lever to strengthen market discipline and encourage sound banking practices.

The first pillar presented two broad methodologies for banks to determine risk weights. The first one, so-called Standardized approach (SA), was meant to be applicable for all banks. Under this approach, the bank loans will be categorized by a small number of risk categories, the risk weight associated with them is based on an external rating, and these risk weights will be computed to determine the level of capital requirements.

The second methodology was the Internal Ratings-Based (IRB) approach. According to the it, loans are assigned individual risk weights based on the bank's internal risk assessment. RWAs are still determined by multiplying the risk-weights by actual asset values, and capital requirements, as in Basel I, are still defined in terms of risk-weighted assets (BCBS, 2006). The amount of the bank's required buffer capital is the product of relative risk weight, exposure at the time of default, and the 8 percent absolute capital requirement.

The IRB technique is calculated at 99.9% confidence level over a one-year horizon. BCBS (2005) states that the IRB approach establishes regulatory capital for credit risk at a level where losses surpass it, "on average, once in a thousand years". Banks must rely on internal estimates of risk components to calculate the level of capital requirements. These components include, for different types of assets:

a) *Probability of default (PD)*: Estimate of the borrower's likelihood of defaulting on his debt services within one year;

b) *Loss given default (LGD)*: Loss on the exposure as a result of the borrower's default, often stated as a percentage of the original nominal value of the debt.

c) *Exposure at default (EAD)*: Nominal value of the borrower's debt including both on and off-balance sheet ;

d) *Effective maturity of the loan (M)*.

Additionally, the current accord gave banks the possibility of choosing to apply the IRB model at one of two sub-versions: the Foundation IRB (F-IRB) and the Advanced

IRB (A-IRB) approaches. Under the former, banks were allowed to estimate the PD while the other parameters were prescribed by the regulator. By contrast, banks that chose the A-IRB approach would have to develop own empirical model to estimate all the parameters required to determine the RWA. Despite the selected approach, the total required capital was calculated as a fixed percentage of the estimated RWA.

Moreover, banks must demonstrate that a certain model has been internally applied for a minimum of three years before regulators accept its use for regulatory purposes. Although the IRB approach is more expensive to maintain since it involves a higher level of complexity (BCBS, 2004) and a greater amount of data on prior loan performance, it results in lower regulatory capital requirements than the SA approach. As a result, banks that follow the IRB method may deploy their capital in search of more (profitable) lending opportunities.

Basel II was designed to give a better evaluation of the actual risks faced by banks (BCBS, 2001) and to restrict the opportunities for regulatory arbitrage, i.e., the concentration of bank credit exposures on categories with low risk weights under the Basel I framework. Furthermore, once a bank implements the IRB strategy for some of its assets, it must implement it across all important portfolios and business lines (BCBS, 2001).

Basel III

The financial crisis of 2007-2009 and the European sovereign debt crisis that followed it have revealed a number of flaws connected to the use of IRB approaches for regulatory capital. These weaknesses included the extreme complexity of the IRB approaches, a lack of comparability of banks' IRB capital requirements, absence of robustness in modelling certain asset classes (Liu, 2021), and banks from many jurisdictions held insufficient amount of capital (Montes et al., 2018). The sudden losses were higher than the levels proposed by the risk weighted assets that determined the capital requirements under the Basel II in BCBS (2006) (Montes et al., 2018). As a reaction, the Basel III framework was introduced.

The reforms introduced by Basel III, rather than replace for Basel II, they complement Basel II. As gathered in BCBS (2010), the improvement in Basel III maintained in its core the technical framework for calculation of RWAs presented in the

Basel II focusing on trials to increase the required amount of capital for a certain size of RWAs.

The Basel III reforms increased the quality of the required level of capital; improved liquidity and stabilize funding; established a back-up minimum leverage ratio; promoted the build-up of capital buffers; and assessed a regulatory capital surcharge on systemically important financial institutions (BCBS, 2010).

Such developments increased the complexity without altering its fundamental basis and thus received criticism. Although Basel III included a leverage ratio (capital over unweighted exposures) to provide a limit against the failings of IRB models, it did not constitute the vital component of the model (Montes et al., 2018).

The Basel III framework is in constant upgrade with the most recently revision of Basel III (BCBS, 2017) removing the option to use the A-IRB approach for certain asset categories; adopting input floors (for metrics such as probabilities of default and loss-given-default) to ensure a minimum level of conservatism in model parameters; and providing superior description of parameter estimation practices to reduce RWA variability (Liu, 2021). Furthermore, the European Banking Authority (EBA) considered that the IRB approach is still the best way to determine credit risk capital requirements (EBA, 2013, 2016).

2.3. The IRB approach in the literature

Since the introduction of the IRB approach, researchers and authorities started an intense debate about its efficiency and trustworthiness. In the center of this debate lies the high complexity of the approach, the degree of discretionarily allowed to bank (Cucinelli et al., 2018) and the blurred rules that may generate high compliance costs and barriers to entry (BCBS, 2004).

Behn et al. (2016b) after analyzing a sample of German banks, found that although single loans and loan portfolios under the IRB approach have lower PD and RWA, they presented a higher actual default rate and loan loss rate than those originated with the SA. Thus, supporting the hypothesis of underreporting. Nevertheless, the interest rates associated with these loans are higher, showing that IRB models have superior discriminatory power and permit a precise risk measurement.

Mariathasan and Merrouche's (2014) study demonstrated that weakly capitalized banks report RWAs values incompatible with their riskiness and discovered evidence that underreporting is the result of strategic risk weight adjustment rather than the use of defective internal models. Also, such reduction in risk-weight is more noticeable in jurisdictions where the legal framework for supervision is low and countries where banking authorities regulate many IRB banks.

The claimed manipulation of risk weights implies a potential flaw in risk reporting, which consists of an issue in terms of the effectiveness and accuracy of internal models. A bank may have an advanced and accurate internal risk model but choose to underreport its own risk (Cucinelli et al., 2018).

Additionally, the costs associated with the application and execution of the IRB are higher compared to the SA, which creates difficulties for small and medium-sized banks to implement this approach (Peter & Mihail, 2010). In fact, larger banks, banks with lower liquidity and equity capital relative to total (unweighted) assets, and better past credit performance are more willing to use the IRB approach (Montes et al., 2018). Nevertheless, even large banks can face obstacles due to the specificities of each national financial system (Peter & Mihail, 2010).

More crucially, by using internal models, banks have significant autonomy in risk assessment, which can give a significant incentive for regulatory arbitrage. Mariathasan and Merrouche (2014) stated that once the regulatory permission for the use of the IRB approach was obtained, the bank's risk-weight density decreased. This implied that part of the decline in reported riskiness with the IRB scheme was due to strategic risk modeling (Mariathasan and Merrouche, 2014).

On the bright side of the IRB approach, Cucinelli et al (2018) offer evidence that banks stick to the IRB approach were capable of limiting the increase in credit risk due to macro economy better than banks under the SA approach.

Although Liu (2021) asserts that banks from peripheral countries in Europe could decrease the risk-weight of their assets in capital requirement computations if they apply more model-based capital rules. The author also points out that the default rate of those bank's assets is not correctly displayed in their capital requirement computations.

As reported by to Stewart (2021) the IRB approach provides more effective risk discrimination across individual exposures, allowing more regulatory capital to be kept against riskier exposures while holding less regulatory capital against less risky exposures. The author further argues that the Basel III output floor, i.e., the lower limit ("floor") on the capital requirements, may disincentivize the use of the IRB approach and consequently, reduce the value of secured lending under the IRB approach.

Moreover, Stewart (2021) argues that if regulatory capital is optimally managed, it increases in regulatory capital can thereby improve loan quality and banking efficiencies, thus benefiting long-term economic growth. Indeed, evidence from Dagher et al. (2020) and Martynova (2015) showed that the regulatory capital recommendation of the Basel III is reasonable to absorb losses from crises and promote economic growth, respectively. Hakenes and Schnabel (2011) further argued that the IRB approach is most effective if employed equivalently across all banks.

Malovana et al. (2019) presented evidence of a significant relationship between monetary policy easing and lower implicit risk weights of IRB banks. The authors add that the IRB model enables a higher sensitivity of capital requirements to the risk structure of banks' assets. Nonetheless, they recognize the fragilities of the approach, including its

dependency on past data and its complexity. Banks can utilize as little as five years of data to calculate their predictions under the IRB technique, whereas the average length of the financial cycle in industrialized economies is believed to be around 15 years, with the upward phase accounting for two-thirds of the cycle. As a result, during the pinnacle of the financial cycle, risk estimations are solely focused on its upward-sloping portion and hence cannot provide an accurate forecast of future losses the economy will incur in a downturn. Consequently, risk weights determined using the IRB approach may be lowest when the hazards are greatest (Malovana et al., 2019) .

On top of that, Behn et al. (2016a, 2016b) demonstrated that when facing the negative economic cycle that followed the great financial crisis, European IRB banks reallocated credit from riskier to safer borrowers as it would limit the undesired increase in credit risk.

In accordance with several regulatory reports and scholarly articles, Basel II risk-weights have a limited risk-sensitivity. BCBS (2009) asserted that some banks may appear to be highly well capitalized based on regulatory capital, but in reality, only hold modest amounts of high-quality capital. Besides, BCBS (2013) demonstrated that one of the primary variables determining risk-weights is variation between banks' modeling choices. According to the Financial Services Authority (2010), a sample of banks was asked to estimate the risk of a shared portfolio using their own internal models, and the banks reacted a widely disparate suggestions of capital requirements.

Although the SA has been criticized for being too simple, the granularity and risk sensitivity of it is greatly improved in the newly proposed Basel III regulations (BCBS 2017). Over 50% of banks in Europe, the Americas, Africa, Asia and Middle East, rely on the SA for calculating capital requirements for credit risk (Hohl et al., 2018).

3. Research Questions

This section the discussion of the research questions will be presented. As expressed in section 2.3., the existing literature is quite ambiguous about the reliability of the IRB approach. Since its stress testing in the afterward of the great financial crisis, in which some of its weaknesses were exposed and consequently upgrade, the pandemic consists in a new opportunity to put the IRB technique to the test.

Therefore, this study fills an important gap in the literature because no study has yet analyzed the of the IRB approach during the Pandemic, which consists in a recent event that lacks in an extensive number of studies.

The goal of this research is to determine how deep was the impact of the Pandemic on commercial banks performance and how differently it affected banks under IRB approach and those under SA approach, i.e., if the adoption of an IRB approach brings competitive advantage to banks.

The following describes the research hypothesis that will be tested:

H1: Banks under IRB approach outperform banks that use SA approach in normal conditions, i.e., before the Pandemic.

H2: The Pandemic had a significant impact on banks that apply SA approach.

H3: The adoption of the IRB approach prevents banks from further loss caused by the pandemic.

Each hypothesis will be tested for all the performance measures, i.e., ROA, ROE and NIM.

4. Data and Methodology

4.1. Sample and Data

This research intends to explore the impact of the pandemic on the performance of European commercial banks under the IRB approach and those on SA approach, from 2017 to 2020. In that sense, year-end consolidated data was extracted from BankFocus and from European Banking Authority (EBA).

For the analysis, it was extracted data of active commercial banks from the major European countries namely: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

The EBA stress tests samples accounted for at least 70% of the total banking sector assets. The emphasis was placed on the parent banks of the banking groups at the country level, as the resulting capital policies and credit risk are typically envisioned and managed primarily at the group level. Therefore, when collecting data from BankFocus it was required to remove any subsidiary bank.

Beside the selection of banks that practice International Financial Reporting Standards (IFRS) and Local Generally Accepted Accounting Principles (GAAP) as suggest by Marques and Alves (2021), and to avoid data duplication, it was considered consolidation code C1, U1 and U2. All data was collected in absolute years, from 2017 to 2020 and all figures are in thousand Euros.

Lastly, it was excluded from the sample banks with missing crucial data regarding the dependent variables. The final sample consist of 397 banks. Table 1 presents the distribution of the total number of banks by country, year and approach. In some cases, it is possible to witness the change of the approach used by banks from SA to IRB and vice-versa.

Table 1: Sample distribution by Country, Year and Approach

Country	Total	2017		2018		2019		2020		2021	
		IRB	SA	IRB	SA	IRB	SA	IRB	SA	IRB	SA
Austria	16	6	10	6	10	6	10	6	10	6	10
Belgium	13	5	8	5	8	5	8	5	8	5	8
Bulgaria	8	0	8	0	8	0	8	0	8	0	8
Croatia	5	0	5	0	5	0	5	0	5	0	5
Cyprus	6	0	6	0	6	0	6	0	6	0	6
Czech Republic	8	2	6	2	6	2	6	2	6	2	6
Denmark	9	3	6	3	6	3	6	3	6	3	6
Estonia	5	0	5	0	5	0	5	0	5	0	5
Finland	9	1	8	1	8	1	8	1	8	1	8
France	34	11	23	**11**	**23**	**10**	**24**	10	24	10	24
Germany	32	10	22	10	22	10	22	10	22	10	22
Great Britain	45	3	42	3	42	3	42	3	42	3	42
Greece	2	1	1	1	1	1	1	1	1	1	1
Hungary	5	0	5	0	5	0	5	0	5	0	5
Iceland	2	0	2	0	2	0	2	0	2	0	2
Ireland	1	0	1	0	1	0	1	0	1	0	1
Italy	25	5	20	5	20	5	20	5	20	5	20
Latvia	6	**0**	**6**	**2**	**4**	2	4	2	4	2	4
Lithuania	2	0	2	0	2	0	2	0	2	0	2
Luxembourg	9	2	7	2	7	2	7	2	7	2	7
Netherlands	18	7	11	7	11	7	11	7	11	7	11
Norway	3	1	2	1	2	1	2	1	2	1	2
Poland	7	0	7	0	7	0	7	0	7	0	7
Portugal	11	**2**	**9**	**3**	**8**	**4**	**7**	4	7	4	7
Romania	2	0	2	0	2	0	2	0	2	0	2
Slovakia	3	0	3	0	3	0	3	0	3	0	3
Slovenia	3	0	3	0	3	0	3	0	3	0	3
Spain	14	4	10	4	10	4	10	4	10	4	10
Sweden	16	4	12	4	12	4	12	4	12	4	12
Switzerland	78	3	75	3	75	3	75	3	75	3	75
Total	397	70	327	73	324	73	324	73	324	73	324

4.2. Variables Description

In this section the dependent, independent and control variables will be addressed and presented, taking into account the different theories proposed in the literature review as well as the hypotheses formulated. This section will be summarized in Table 2.

4.2.1. Dependent Variables

The performance of the banks (i.e., the dependent variable) will be measure as their return on asset (*ROA*), return on equity (*ROE*) and net interest margin (*NIM*) as presented in different studies on bank performance (Dietrich & Wanzenried, 2011; Borroni et al., 2016; Nikolić et al., 2022).

Return on Assets

ROA is expressed as the ratio between net income and total assets. It can also be represented by the product of the profit margin and asset utilization ratios. ROA measures how much profit is generated, on average, per euro of assets and indicates how successfully the bank's assets are being managed to create income. Although it is a fundamental metric of bank profitability that accounts for the bank's size, it may be skewed due to off-balance-sheet activity.

Return on Equity

ROE is defined as the ratio of net income to total equity. It is the measure of bank's profitability generated by the shareholders' investment.

Net Interest Margin

NIM corresponds to the difference between interest income and interest expenses as a percentage of total assets, i.e., it focuses on the profit earned on interest activities. A basic intermediation role of a bank is to issue liabilities and use the proceeds to purchase income-generating assets. The NIM will be high if a bank manager has done an excellent job of asset and liability management, such that the bank earns solid income on its assets while incurring modest costs on its liabilities.

4.2.2. Independent Variables

Once the methodology used in this research is Difference-in-Difference, that will be further explained in section 4.4., the independent variables are two dummy variables and the interaction between them. One of them, *IRB*, which takes the value of zero is the bank uses the standardized approach and one if it uses a pure IRB approach or a mixed between the two approaches. The other dummy, *PANDEMIC*, takes the value of zero if the period is before the emergence of the Pandemic (data from 2017 to 2019[2]) and one for the next years.

4.2.3. Control Variables

Naturally, there are other factors influencing the impact of the pandemic on the bank's performance. Hence, to control for other influences on the dependent variables, it will be considered some control variables in this study. Therefore, it will be considered, following studies from Groppe et al. (2011), Schiozer et al. (2018) and Merikas et al. (2020), variables at bank-level and macroeconomic-level.

Bank-level controls include bank size (measured as the natural logarithm of assets), liquidity (calculated by the ratio between liquid assets and short-term liabilities). The addiction of these variables is justified by the possibility of investors to alter their investment to larger banks or banks more diversified, and/or banks with more liquidity in periods of trouble (Schiozer et al., 2018). With more resource, larger and more liquid banks can invest in riskier assets and get more return.

Macroeconomic controls will include the Herfindahl-Hirschman index (which captures the concentration of the banking market), and the countries' GDP per capita.

[2] Although the Covid-19 Pandemic emerged in the end of 2019 in China, the first case in Europe was reported on January 24th, 2020, in France (Euronews, 2020)

Table 2: Variables Description and source

Variables	Description	Source
Dependent Variables		
ROA – Return on Assets		BankFocus
ROE – Return on Equity		BankFocus
NIM – Net Interest Margin		BankFocus
Independent Variables		
IRB	Dummy variable that equals 1 if bank uses validated IRB model	European Banking Authority and banks 'report
PANDEMIC	Dummy variable that equals 1	
IRB x PANDEMIC	Interaction between IRB and PANDEMIC	
Control Variables		
SIZE	Natural logarithm of total assets	BankFocus
LIQ - Liquidity	Ratio of liquid assets over short-term liabilities and deposits	BankFocus
HHI - Herfindahl-Hirschman index	Concentration of banking business (based on total assets)	European Central Bank (Statistical Data Warehouse)
GDPpc	Gross Domestic Product per capita	Eurostat

4.3 Descriptive Statistics

In this section, Table 3 presents the descriptive statistics for the different variables at bank level. The banks are slitted between those under IRB approach and SA approach, both before and after the COVID-19 pandemic.

When analyzing the pre-pandemic period, the banks stuck to the IRB approach presented, on average, higher *ROA* than that of banks that used SA approach, but the difference is not statistically significant. During the pandemic period, both groups presented a decline in the ratio, but the reduction was more pronounced in banks that applied IRB approach. Nevertheless, the difference between the groups remained statistically insignificant.

Concerning the *ROE*, once again, banks under IRB approach presented, on average, a superior value compared to banks that used SA approach, and the difference is statistically significant implying that IRB banks presented better returns to shareholders. There was a decrease on the *ROE* for both groups during the pandemic and banks stuck to SA approach presented slightly better results, however the difference between them turned statistically insignificant.

NIM is the only dependent value that persisted, on average, higher for SA banks that IRB bank, both before and throughout the pandemic and statistically significant despite the reduction caused by the crisis.

The statistics description in Table 3 also indicates that banks that used the IRB approach were, on average, larger in *SIZE* both prior and during the pandemic, as expected due to the costs of implementing the IRB method as point out by Peter et al., 2010. The difference is statistically significant at the two periods in analysis. Surprisingly, the average size of banks of both groups increased during the pandemic period.

While banks stuck to the IRB approach had on average higher ratio liquid assets to short-term liabilities contrasted to SA banks, both groups increase their liquidity ratios through the pandemic. The difference between them in both periods continued statistically significant.

Finally, for the macroeconomic variables, despite the small difference in the concentration of banking business captured by *HHI*, it endured statistically significant through periods, and even increased by 0.007 points within the same bank group. As for *GDPpc*, banks that applies IRB approach are located in countries with higher *GDPpc*, on average, compared to countries with banks under SA approach. The difference is statistically significant in both periods regardless of the drop suffered through the Pandemic.

Table 3: Descriptive Statistics

	IRB = 0					IRB = 1					
Variables	**Obs.**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Obs.**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Difference**
PANDEMIC = 0											
ROA	975	0.486	1.734	-14.985	18.540	216	0.853	2.892	-4.055	29.142	-0.367
ROE	975	5.228	17.533	-69.568	428.000	216	6.409	11.859	-51.390	61.495	-1.182***
NIM	975	2.256	3.149	-6.138	55.036	216	1.085	0.887	-0.273	5.159	1.171***
SIZE	975	14.115	1.709	9.888	20.079	216	17.796	2.269	11.181	21.080	-3.681***
LIQ	975	87.588	536.293	0.109	12664.74	216	219.830	937.301	5.546	7839.600	-132.242***
HHI	612	0.100	0.064	0.025	0.270	195	0.091	0.061	0.025	0.257	0.010**
GDP	612	30237.71	15063.86	6120	84020	195	35121.64	11877.23	12140	84020	-4883.93***
PANDEMIC = 1											
ROA	648	0.358	1.864	-21.099	20.209	146	0.341	1.107	-4.059	7.593	0.017
ROE	648	2.942	16.643	-254.286	87.850	146	2.567	12.515	-62.748	37.031	0.375
NIM	648	1.985	2.268	-4.316	30.828	146	0.998	1.040	-5.478	5.906	0.987***
SIZE	648	14.267	1.744	9.807	20.155	146	17.830	2.376	10.354	21.224	-3.563***
LIQ	648	98.439	636.052	0.157	14099.13	146	237.897	1148.149	9.688	9664.549	-139.458***
HHI	406	0.107	0.064	0.029	0.258	132	0.098	0.060	0.029	0.232	0.009*
GDP	406	29967.29	14971.55	6410	84490	132	33914.09	12370.81	12340	84490	-3946.80***

Notes: The discrepancies in the number of both observations and clusters are due to data unavailability. The difference between the means were tested using the Wilcoxon rank-sum test. The statistical significance is represented by the symbols (*), (**), and (***) at 10%, 5%, and 1%, respectively.

Analyzing the performing metrics by country for banks under IRB approach and those under SA approach, it possible to infer that, regarding *ROA* and *ROE*, the results tend to be higher for IRB banks them for SA bank. Belgium, Italy, Luxembourg, Spain and Switzerland are country where the opposite occurs, i.e., banks stick to SA approach present better results.

As for *NIM*, banks under SA approach tend to perform better outcomes than banks under IRB approach. Czech Republic, Greece, Latvia, the Netherlands, Norway and Portugal are some exceptions. Table 4 summarizes the comparison between countries.

Table 4: Country comparison for performing metrics by bank approach

Country	IRB =0			IRB =1		
	ROA	**ROE**	**NIM**	**ROA**	**ROE**	**NIM**
Austria	0.526	5.216	1.258	0.878	6.748	1.149
Belgium	0.536	5.733	1.497	-0.237	-2.857	0.821
Czech Republic	0.720	38.427	1.577	0.751	16.219	1.966
Denmark	1.517	6.903	4.425	0.839	8.009	0.798
Finland	0.353	2.975	1.298	0.354	8.024	0.606
France	0.301	2.629	1.646	0.281	5.400	0.497
Germany	-0.105	0.783	2.031	0.058	1.033	0.892
Great Britain	0.265	1.671	2.317	5.700	14.828	0.186
Greece	-2.269	-35.495	2.197	0.197	1.956	3.331
Italy	0.722	3.377	3.232	0.214	0.802	0.913
Latvia	0.848	8.113	2.230	1.576	9.068	2.331
Luxembourg	0.612	8.297	3.196	0.442	5.522	1.279
Netherlands	0.328	3.496	1.726	1.119	8.121	1.076
Norway	0.764	6.991	1.338	1.028	11.460	1.535
Portugal	-0.966	-2.985	1.974	-0.176	-2.649	2.264
Spain	0.459	5.704	1.184	0.352	3.956	1.659
Sweden	0.806	5.356	3.501	0.682	10.391	0.946
Switzerland	0.384	4.008	1.177	0.219	0.658	0.687

Notes: Bulgaria, Croatia, Cyprus, Estonia, Hungary, Iceland, Ireland, Lithuania, Poland, Slovakia and Slovenia were excluded from the comparison as there are no banks under IRB approach.

Table 5 exhibits the correlation matrix for the explanatory variables. As expected, *SIZE* and *IRB* present some degree of correlation, as larger banks are more likely to adopt an IRB approach. Nevertheless, the value presents no concerns with the correlation between them. Likewise, the lowest negative value -0.250, is not close to serial correlation.

Table 5: Correlation Matrix

	LIQ	SIZE	IRB	PANDEMIC	HHI	GDPpc
LIQ	1.000					
SIZE	-0.049	1.000				
IRB	0.076	**0.606**	1.000			
PANDEMIC	0.009	0.029	0.003	1.000		
HHI	0.004	-0.008	-0.026	0.117	1.000	
GDPpc	-0.046	0.026	-0.045	0.006	**-0.250**	1.000

4.4. Methodology and Model Specification

Differently from Global Financial Crisis, the Covid-19 Pandemic did not result from unravelling previous financial imbalances, been truly exogenous. Difference-in-Differences (Diff-in-Diff) estimators are typically used to analyze the treatment effects of natural or quasi-natural experiments that trigger changes in the environment of a specific group. Instead of analyzing the differences in just one group, Diff-in-Diff investigates the treatment effects by looking at the difference between differences in two groups.

The Diff-in-Diff criteria is satisfied as there are two groups of banks (those under the IRB approach and those stick to SA approach) and two time periods (before the pandemic and during). Banks which implemented the IRB will be considered the treated group and the other ones, the control group. Once the use of treatment is differentiated by the time, data from 2017-2019 will be considered years before the pandemic, and data from 2020-2021 will be considered during the pandemic.

Schiozer et al. (2021) do not recommend the use of too long periods in the Diff-in-Diff methodology, as the dependent variables can be affected by the occurrence of other events beyond the one in analyze and lead to biased conclusions. On the other hand, using too few years before the shock will not make it possible to verify parallel trends. Thus, a 5-year period will be considered enough.

The analyze will be expanded by adding control variables and fixed effects (bank. country and year) in the model, and the econometric model is as follows:

$$Y_{i.t} = \beta_0 + \beta_1 PANDEMIC_t + \beta_2 IRB_i + \beta_3 (PANDEMIC\ x\ IRB)_{i.t} + \sum_{k=1}^{K} \Upsilon_k * Z_{k.i} + u_{i.t} \quad (4.4.1)$$

Where:

i – Bank's ID;

t – observation time period;

$Y_{i.t}$ – stands for the dependent variable of bank i in period t (ROA. ROE or NIM);

$$Pandemic = \begin{cases} 1.\ years\ after\ the\ pandemic \\ 0.\ otherwise \end{cases}$$

$$IRB = \begin{cases} 1.\ if\ the\ bank\ is\ under\ IRB\ or\ mixed\ approach\ (treatment\ set) \\ 0.\ otherwise\ (control\ set) \end{cases}$$

$Z_{k.i}$ – represents the vector of control variables (SIZE. LIQ. HHI and GDP)

Regarding the coefficients, β1 indicates the differences among the untreated group (SA banks) in the periods (before and during the pandemic); β2 describes the differences between the IRB and SA banks in the pre-pandemic period; β3 is the most important coefficient, which captures both the time effect and the treatment effect. In other words, it captures the difference between the observed average post-pandemic ROA, ROE or NIM and the average unobserved counterfactual ROA, ROE or NIM after the pandemic. Thus, if β3 is significant and positive one might conclude that IRB adoption has a positive effect on the dependent variable of bank quotes.

5. Results

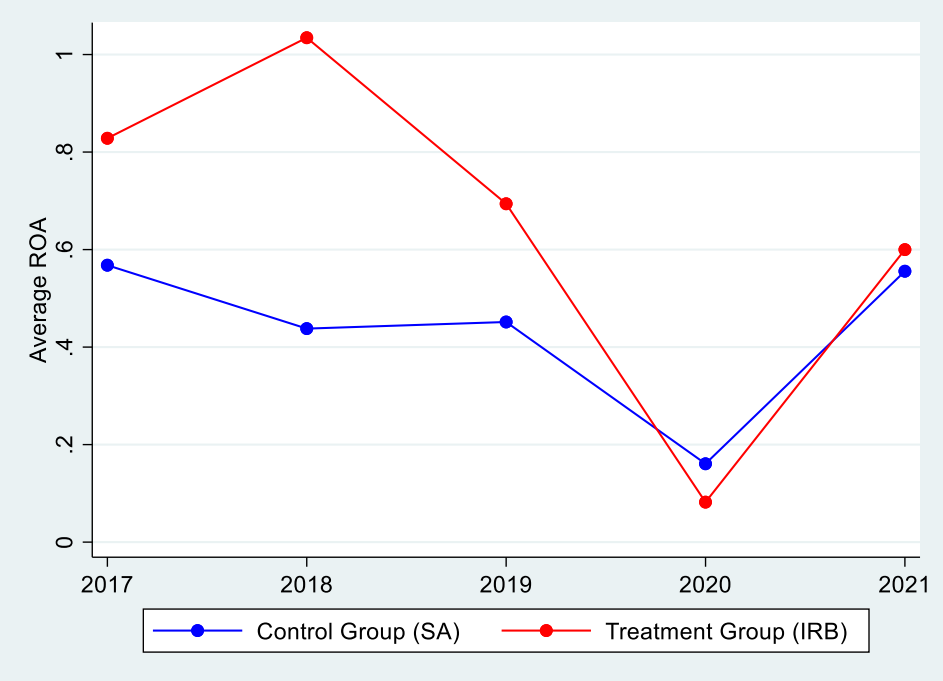
5.1 Parallel Trends

One of the main assumptions of the Diff-in-Diff methodology is the parallel trends assumption prior to the shock. It states that the dependent variables for treated, and control group should move in the same direction and same proportion before the pandemic. This presumption is represented graphically by saying that treated banks' and controls' pre-shock trends are parallel and would have remained parallel in the absence of pandemic. (Schiozer et al., 2021).

Figure 1 describes the average ROA progress of banks under SA approach (control) and under IRB approach (treatment) from 2017 to 2021. The difference between the ROA value of the two groups can be visualized through the period, in which the treatment group present higher values than the control group, excluding for the year of 2020.

Prior to the pandemic, the ROA of both groups has decreased from 2017 to 2019, although it has raised for IRB banks in 2018. For that matter, it will be considered that the trends are roughly parallel before the pandemic. This issue will be further explored in the robustness checks. Moreover, it is possible to perceive the impact in the first year of the Pandemic, being more noticeable for banks that applies IRB approach.

Figure 1: ROA evolution by bank group

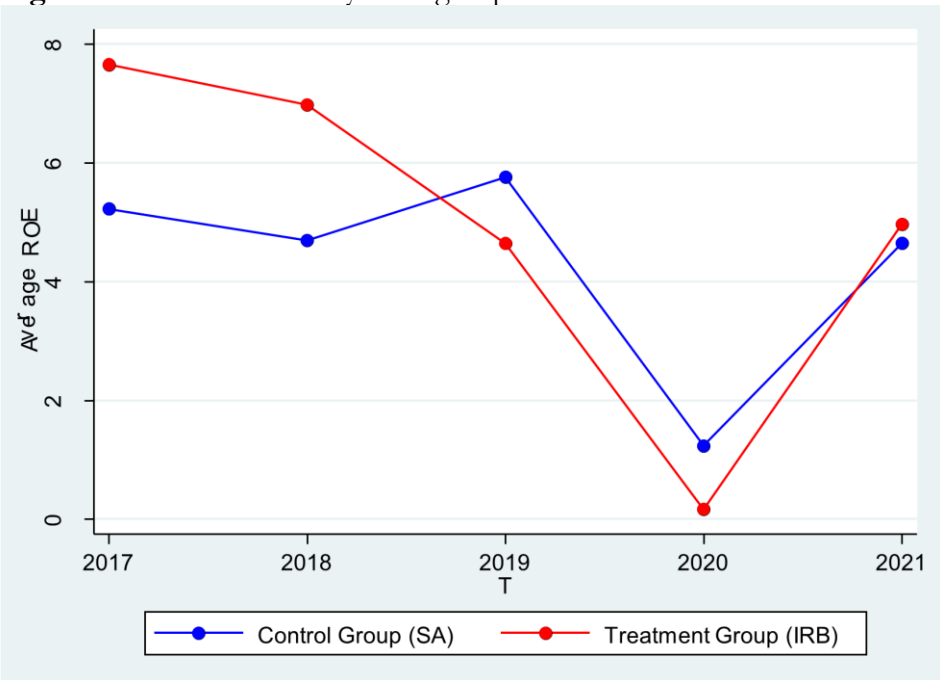


Notes: The average ROA represents the mean of all banks by each year.

Figure 2 illustrates the average ROE of banks stuck SA approach (control) and sticked IRB approach (treatment) from 2017 to 2020. The treatment group outperformed the control group in the in the early years, being surpassed by the control group immediately before and after the beginning of the Pandemic, then recovering in late 2021.

During the pre-Pandemic period the trends were visible parallel from 2017 to 2018. After that, from 2018 to 2019 the groups presented opposite trends, i.e., the control group increased the value of ROE, while the treatment group decreased. This trend may undermine the Diff-in-Diff assumption, but for the time being, they will be considered parallel.

Figure 2: ROE evolution by bank group

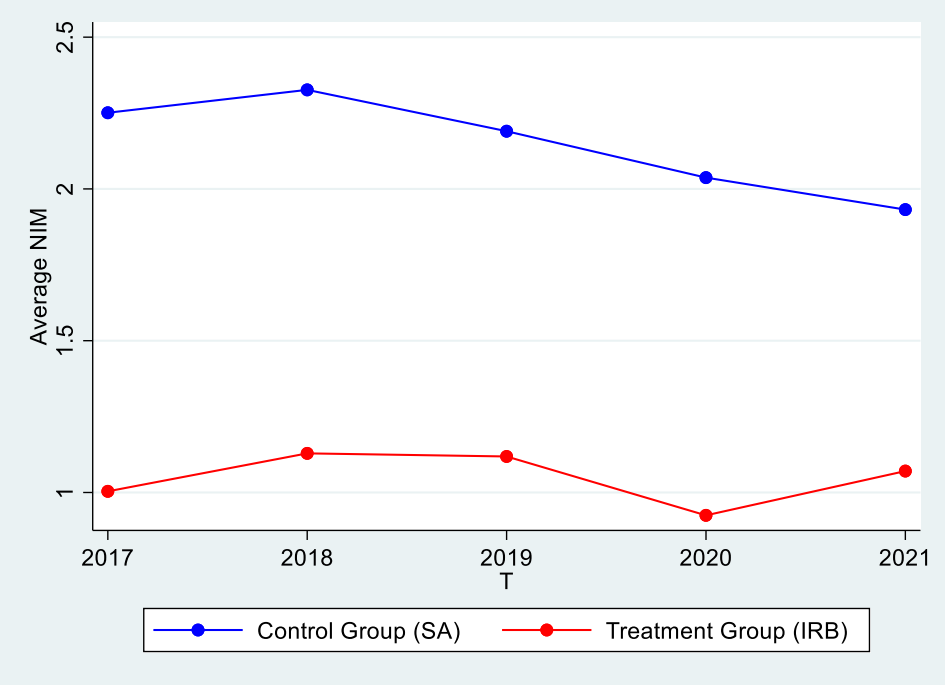


Notes: The average ROE represents the mean of all bank stich to its respective approach in each year.

Lastly, Figure 3 expresses the average NIN of banks that use SA approach (control) and those that use IRB approach (treatment) from 2017 to 2020. NIM is the only performance variable that was outperformed by the same group through all the period in analysis, that is, the control group. Nevertheless, the control group present a decreasing movement, while the treatment group's movement is more stable.

In the pre-crisis period, the NIM of SA banks has slightly diminished whereas the IRB banks' NIM has slightly improved. Nonetheless, their trends will be considered parallel for the analysys.

Figure 3: NIM evolution by bank group



Notes: The average ROA represents the mean of all bank stich to its respective approach in each year.

The section 5.3. will give additional robustness assessments. However, for now, the visual examination will be sufficient to state that the trajectories in both charts are generally parallel throughout the pre-treatment periods and that the identification condition for the Diff-in-Diff model is satisfied for moving forward with the regressions.

5.2 Diff-in-Diff analysis

Table 6 exhibits the estimation of equation (4.4.1) with the variations mentioned in the previous section. The first three columns present the traditional form of the Diff-in-Diff methodology.

In the first column, the coefficient β_1 (*PANDEMIC*) suggests that the *ROA* decreased for the SA banks from the pre-pandemic period to the pandemic period. However, it is not statistically significant at the usual levels. The estimation of β_2 (*IRB*) is also not statistically significant at 10% level, so, the average pre-pandemic *ROAs* of both groups are not significantly different. Lastly, the coefficient β_3 that captures both the time effect and the treatment effect for the bank groups is not statistically significant at the usual levels too.

Evaluating the second column is possible to infer that that the *ROE* decreased 1.852, on average, for the control group (SA banks) between the two period in analyze as pointed out by β_1 (*PANDEMIC*). This value is statistically significant at the 5% level. However, β_2 (*IRB*) and β_3 (*IRB x PANDEMIC*) are not significant at usual levels, indicating that neither the average *ROE* of the IRB banks and SA banks are significantly different prior to the beginning of the pandemic, nor the difference on the impact caused by the pandemic on their *ROE* was significant, respectively.

Regarding the *NIM* (column 3), the estimation of β_1 (*PANDEMIC*) proposes that the *NIM* of SA banks decreased 0.271 from the pre-pandemic period to pandemic period with a statistical significance level of 1%. Furthermore, the average *NIM* of the IRB banks and SA banks are significantly different at 1% level in the pre-pandemic period as suggested by β_2 (*IRB*). Again, β_3 (*IRB x PANDEMIC*) is not significant at usual levels.

In the columns 4, 5 and 6, new features were added to the basic Diff-in-Diff regression, the bank-level control variables, namely *Size* and *LIQ*. In general, the inclusion of this variables improved the precision and regression fit of the model. Once bank size is correlated with the treated variable (*IRB*), this can lead to an omitted variable problem. Consequently. the results of the three first columns could be wrongly attaching the changes in the dependent variables to the implicit guarantees, and not to their size or liquidity.

The outcomes in column 4 imply that *Size* and *LIQ* are not statistically significant at 10% level to influence the results of ROA. Again, the coefficients for *PANDEMIC*, *IRB* and *IRB x PANDEMIC* remained not statistically significant.

Analyzing the ROE in column 5, none of the control variables added (*SIZE* and *LIQ*) has a statistically significance at the usual levels. Moreover. the conclusions about β_1 (*PANDEMIC*), β_2 (*IRB*) and β_3 (*IRB x PANDEMIC*) remained the same as in column 2 and the β_2 is now statistically significant at 1% level. This shows that the previous inferences can withstand the addition of these factors.

Size and *LIQ* have negative relation with the NIM as presented in column 6 and they are statistically significant at 1% and 5% level, respectively. NIM is the only dependent variable where these controls are significant. The coefficients for *PANDEMIC*, *IRB* and remained stable compared to the estimates in column 3, although β_2 significance level changed to 10%. More important, β_3 (*IRB x PANDEMIC*) gained significance at the 5% level. β_3 indicates that, on average, the *NIM* of IRB banks increased more than the value of SA banks. Moreover, it suggests that IRB banks suffered less impact on their *NIM* from the pandemic, comparing to SA banks.

In columns 7, 8 and 9, control variables at the country-level were included to address the possibility that country characteristics may be important in affecting a bank's *ROA*, *ROE*, and *NIM*. However, more than six hundred observations were lost due to missing data from countries that do not belong to the European Union, such as Iceland. Norway, Switzerland and, more recently, United Kingdom.

The coefficient of *HHI* and *GDPpc* variables are not statistically significant to explain ROA variation. Additionally, β_1 (*PANDEMIC*), β_2 (*IRB*) and β_3 (*IRB x PANDEMIC*) stayed statistically insignificant.

Also, considering the *ROE* in column 8, neither *HHI* nor *GDPpc* coefficients are statistically significant at usual levels. Nevertheless, the conclusions about β_1 (*PANDEMIC*), β_2 (*IRB*) and β_3 (*IRB x PANDEMIC*) continued the same as in column 2, i.e., *ROE* decreased, on average, for the control group (SA banks) between the two period in analyze as pointed out by β_1 (statistically significant at the 5% level), β_2 and β_3 persisted not significant at usual levels.

In column 9, none of the coefficients of *HHI* and *GDPpc'* are statistically significant at the 10% level. Regarding the main coefficients, β_1 (*PANDEMIC*) and β_2 (*IRB*) continued statistically significant along with *SIZE*, however β_2 (*IRB*) and *LIQ* are no longer statistically significant as in column 6.

Lastly, in Table 7 the basic Diff-in-Diff model is modified to consider country, bank and year-fixed effects. In columns 10-12 the country-level controls were substituted by country fixed effects. Those effects may capture additional time-invariant country characteristics that macroeconomic controls do not, such as market microstructure. regulatory quality, legal enforcement, and other institutional elements (Schiozer et al., 2021).

By adding the country fixed effects, β_1 (*PANDEMIC*), β_2 (IRB) and β_3 (*IRB x PANDEMIC*) are still not statistically significance. That means that the difference on the ROA of banks under SA approach before and during the pandemic, and the difference between banks that used SA and those that used IRB before the pandemic, are not statistically significant.

Concerning the *ROE* (column 11), the signs and statistical significance of β_1 remained unchanged relative to column 8, although its magnitude has varied. β_2 (*IRB*) and β_3 (*IRB x PANDEMIC*) lasted statistically insignificant at usual levels. As for NIM presented in column 12, all the variables are statistically significant at least at the 10% level and the conclusions are the same presented in column 6.

From columns 13-18, bank fixed effect was added. As a result, bank-level controls were excluded from the estimations. Additionally, due to the collinearity with the *IRB* dummy, this variable is no longer present in the estimation. The β_1 (*PANDEMIC*) that was negative and statistically significant for *ROE* and *NIM* (at the 5% level), while staying statistically not significant for *ROA* as in previous regressions. β_3 (*IRB x PANDEMIC*) continued statistically insignificant for *ROA* and *ROE* and turned statistically insignificant for *NIM*.

Apart from bank fixed effect, year fixed effect was also made present in columns 16-17. This effect is highly correlated with the PANDEMIC dummy, resulting in the exclusion of the latter. Hence, only the coefficient of interest β_3 (*IRB x PANDEMIC*) is

identified. Although, its magnitude and sign remained the same as in the previous regressions, it is not statistically significant at the usual levels.

Furthermore. the introduction of fixed effects resulted in a significant increase in regression fitness, as indicated by the observed variance of the R-squared, particularly when the bank fixed effects were inserted. It implies that the bank-fixed effects account for a substantial portion of the variation in the dependent variables. As a result, characteristics such as the bank's management style and business strategy may be more essential in understanding a bank's ROA. ROE or NIM variation, to the point where the adoption of IRB or SA approach becomes meaningless.

To summarize, concerning ROA although there is a positive difference between IRB banks and SA banks in the pre-pandemic period, it is not statistically significant, thus the hypothesis one is rejected. Additionally, there is a negative impact on the SA banks' ROA however, it is not statistically significant and the hypothesis two is also rejected. Lasty, hypothesis three is rejected too as β_3 is not statistically significant. All the hypotheses remained rejected even after considering bank-level controls, macroeconomic-level controls, country fixed-effects, bank fixed-effects and year fixed-effects.

In relation to ROE only the hypothesis two is accepted, that is, the pandemic had a significant negative impact on SA banks' ROE. Hypotheses one and three are rejected as their respective coefficients are not statistically significant. The inferences stayed the same by adding controls and fixed-effects.

Finally, the hypothesis one is rejected when considering the NIM. However, the rejection is not related with the significance level but with the fact that the banks under SA approach outperformed banks under IRB approach and not the other way around as stated in the hypothesis. Besides the better performance of SA banks in the pre-pandemic period, the crisis had a significant negative impact on the value of their NIM. Hence, hypothesis two is not rejected. Ultimately, when controlling for bank-level variables, macroeconomic-level variables or country fixed-effects, the hypothesis three is accepted meaning that the adoption of the IRB approach prevented banks from further losses.

Table 6: Difference-in-Difference estimation

VARIABLES	(1) ROA	(2) ROE	(3) NIM	(4) ROA	(5) ROE	(6) NIM	(7) ROA	(8) ROE	(9) NIM
PANDEMIC	-0.128	-1.852**	-0.271***	-0.120	-1.893***	-0.237***	-0.145	-2.765**	-0.315**
	(-1.70)	(-3.18)	(-3.65)	(-1.58)	(-3.33)	(-3.57)	(-1.50)	(-3.20)	(-3.16)
IRB	0.367	1.616	-1.171***	0.546	0.634	-0.434*	0.112	-0.740	-0.432
	(1.18)	(1.24)	(-5.93)	(1.10)	(0.32)	(-2.11)	(0.47)	(-0.37)	(-1.57)
IRB x PANDEMIC	-0.384	-1.991	0.184	-0.394	-2.048	0.222**	-0.0338	-0.592	0.278*
	(-1.26)	(-1.55)	(1.77)	(-1.24)	(-1.56)	(2.83)	(-0.27)	(-0.45)	(2.45)
SIZE				-0.0430	0.323	-0.212**	-0.0381	0.295	-0.286**
				(-0.67)	(1.19)	(-3.02)	(-0.77)	(0.90)	(-2.99)
LIQ				-0.000108	-0.000751	-0.000174*	-0.000483	-0.00150	-0.000183
				(-0.29)	(-0.90)	(-2.48)	(-1.16)	(-1.15)	(-1.95)
HHI							2.017	13.77	2.525
							(1.41)	(1.38)	(1.02)
GDPpc							4.27e-06	2.91e-06	-6.59e-06
							(0.89)	(0.60)	(-0.40)
Observations	1.985	1.985	1.985	1.985	1.985	1.985	1.335	1.335	1.335
R-squared	0.006	0.008	0.028	0.009	0.012	0.051	0.035	0.017	0.074
Country FE	NO	NO	NO	NO	NO	NO	NO	NO	NO
Bank FE	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year FE	NO	NO	NO	NO	NO	NO	NO	NO	NO
# of clusters (banks)	397	397	397	397	397	397	267	267	267

Notes: The discrepancies in the number of both observations and clusters are due to data unavailability. Parentheses indicates robust standard errors at bank level. The statistical significance is represented by the symbols (*). (**). and (***) at 10%. 5%. and 1%. respectively.

Table 7: Difference-in-Difference estimation with fixed effects

VARIABLES	(10) ROA	(11) ROE	(12) NIM	(13) ROA	(14) ROE	(15) NIM	(16) ROA	(17) ROE	(18) NIM
PANDEMIC	-0.121	-1.912***	-0.242***	-0.127	-1.970**	-0.269**			
	(-1.58)	(-3.32)	(-3.62)	(-1.51)	(-2.93)	(-3.23)			
IRB	0.721	1.254	-0.531*						
	(1.30)	(0.58)	(-2.28)						
IRBPANDEMIC	-0.383	-1.994	0.218**	-0.385	-1.717	0.158	-0.385	-1.717	0.158
	(-1.20)	(-1.49)	(2.69)	(-1.14)	(-1.20)	(1.40)	(-1.14)	(-1.20)	(1.40)
SIZE	-0.0561	0.241	-0.171*						
	(-0.81)	(0.83)	(-2.25)						
LIQ	-0.0000847	-0.000448	-0.000170*						
	(-0.25)	(-0.54)	(-2.28)						
HHI									
GDPpc									
Observations	1.985	1.985	1.985	1.985	1.985	1.985	1.985	1.985	1.985
R-squared	0.051	0.098	0.165	0.543	0.562	0.893	0.549	0.570	0.893
Country FE	YES	YES	YES	---	---	---	---	---	---
Bank FE	NO	NO	NO	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	NO	NO	YES	YES	YES
# of clusters (banks)	397	397	397	397	397	397	397	397	397

Notes: The discrepancies in the number of both observations and clusters are due to data unavailability. Parentheses indicates robust standard errors at bank level. The statistical significance is represented by the symbols (*), (**), and (***) at 10%, 5%, and 1%, respectively.

5.3 Robust test

A typical robustness checks for the Diff-in-Diff is extending by one year of each end of the sample, i.e., ranging from 2016 to 2022 (Schiozer et al., 2021). Although, increasing the number of periods can bring to the sample unforeseen events adding noise and consequently impact the results, as stated before, if the quality of the estimates sustains, it may strengthen the original hypotheses. However, due to data unavailability, this test cannot be performed.

Another type of robustness check is checking for treatment reversals. Schiozer et al. (2021) states that by reversing the treatment, the expected effect should be the opposite that was verified with treatment. If the opposite effect is demonstrated, then the treatment effect become more credible, as it is challenging to assign the original results to an alternative shock. Again, due to data unavailability, this test cannot be performed as it would be needed data from years after the Pandemic.

Lastly, it can also be used a non-parametric version of Diff-in-Diff (Gonçalves et al., 2018; Schiozer et al., 2021) to execute robustness checks. This check attempts to reinforce the assumption of parallel trends made in previous sections before conducting the regression. It also aids in determining the treatment's long-term effect, such as whether it was permanent or transitory, and whether it occurred all at once or gradually, in which case we should expect to see a gradual increase in value over time.

The non-parametric version of Diff-in-Diff is presented as follows:

$$Y_{i.t} = \beta_0 + \beta_1 POST_t + \beta_2 IRB_i + \sum_t \omega_t \, (POST_t \; x \; IRB_i) + u_{i.t} \qquad (5.3.1)$$

where $POST_t$ is equal to 1 if $time = t$, and o otherwise. There are series of interactions between the treatment dummy and each year of data, with the exception of one of them, usually the first year of data. As a result, the difference in the *ROA*, *ROE* or *NIM* between IRB and SA banks on each date relative to the difference in the sample's first date, is captured by the coefficients ω_t.

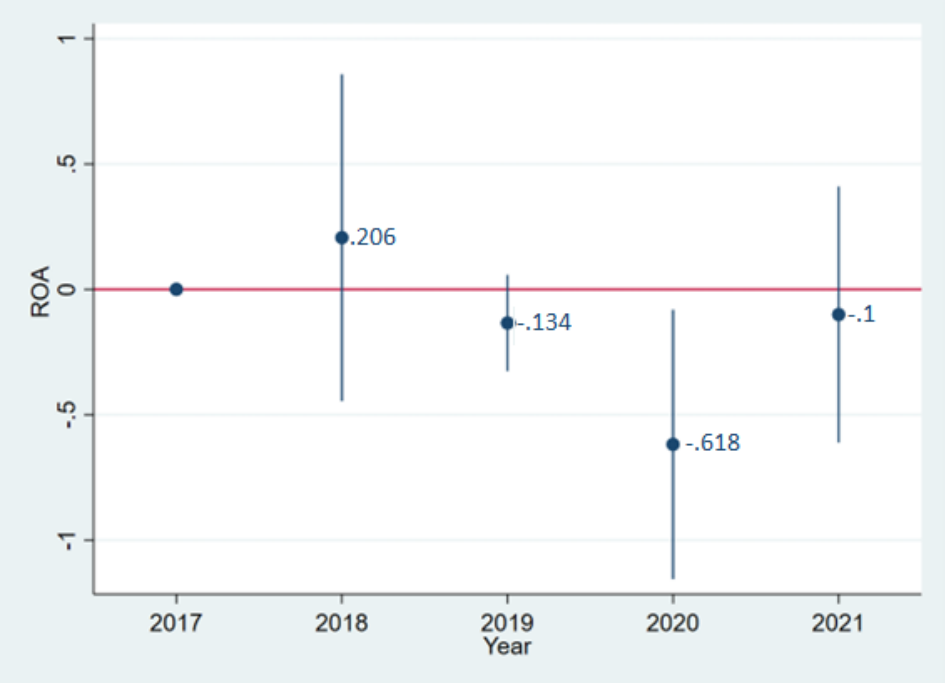
As the non-parametric regression does not rely on a subject judgment about the timing of treatment, it is especially beneficial when the timing of treatment is not a prompt event. Moreover, it can be assured that the pre-pandemic trends of the banks under IRB

approach and those under SA approach were parallel if the value of any ω before the pandemic is statistically equal to 0.

Therefore, the non-parametric version of Diff-in-Diff was estimated in accordance with equation (5.3.1). Furthermore, the statistically significant controls (*Size* and *LIQ*) found in the previous regressions in Table 6 and 7 were added when performing the non-parametric Diff-in-Diff for *NIM*. The results will be presented in graphs rather than in table as it permits an easy analysis of the coefficients.

Figure 4 depicts the vector of coefficients ω_t with their 95% confidence interval for ROA. The figure holds the parallel trends assumption during the pre-Pandemic period as the values of ω_{2018} and ω_{2019} are not statistically different from zero because their vertical bars intersect the horizontal axis. The coefficient ω_{2020} is negative and statistically different from zero, confirming the idea that the pandemic had negative effects in 2020 and the banks under IRB approach had a decrease in their ROA during the period. Nevertheless, this effect appears to fade away in 2020 as ω_{2021} is negative but in less magnitude than in 2021 and it is not statistically significant.

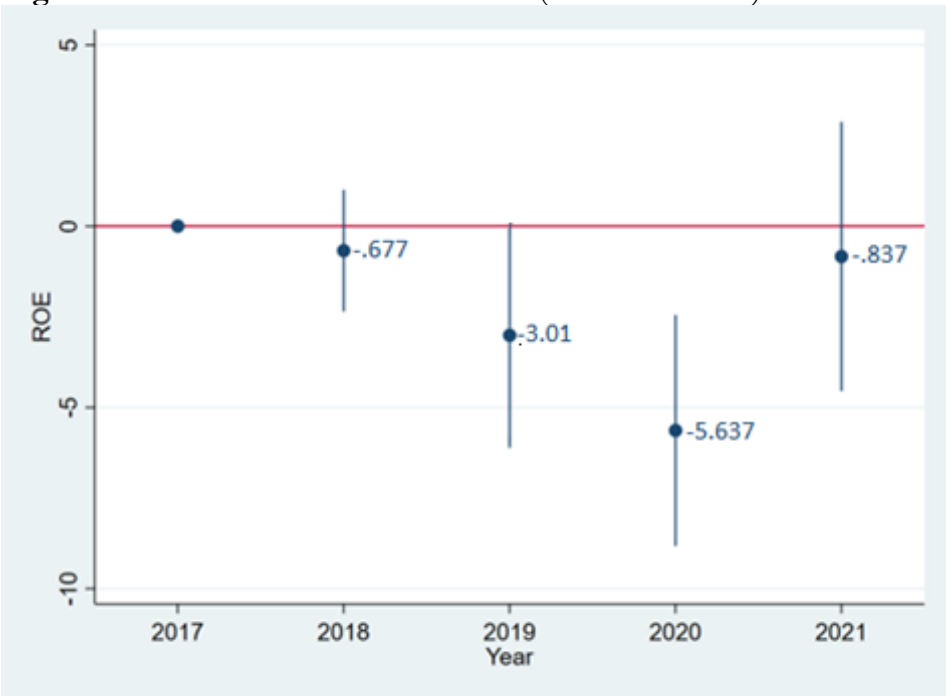
Figure 4: ROA treatment effect over time (without controls)



Notes: ROA is the dependent variable of the regression. The dots represent the value of coefficient ω_t of each, and the vertical line limits its confidence interval at the 95% level.

In Figure 5, the results for the estimation of ω_t are plotted. The values of ω_{2017} and ω_{2018} are not statistically different from zero because they cross over the horizontal axis. The coefficient ω_{2020} is negative and statistically different from zero. Therefore, banks under IRB approach diminished the value of ROA more than banks that apply SA. Once again, the effect fades away in 2021 as ω_{2021} is not statistically different from zero.

Figure 5: ROE treatment effect over time (without controls)



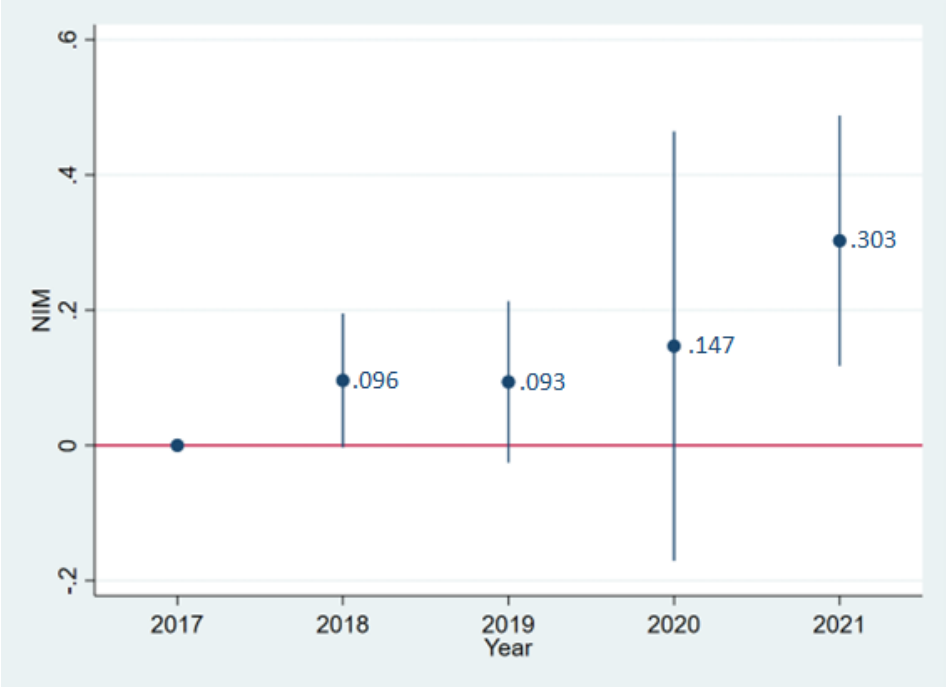
Notes: ROA is the dependent variable of the regression. The dots represent the value of coefficient ω_t of each, and the vertical line limits its confidence interval at the 95% level.

Lastly, Figure 6 illustrates the estimation of ω_t for the NIM. This time, the regression is controlled for SIZE and LIQ as they were the only statistically significant variables presented in Tables 6 and 7. The parallel trends assumption cannot be rejected because the confidence intervals of ω_{2018} and ω_{2019} cross the horizontal axis, even though the confidence interval for ω_{2018} crosses it for a very small margin. Therefore, the coefficients are not statistically different from zero.

The coefficient ω_{2020} is higher and still not significant at the 95% level meaning that the banks that use IRB approach and those using SA approach had parallel trends during the first year of the pandemic. Only in 2021 the difference is statistically significant

indicating that banks under IRB approach increased their NIM more than banks under SA approach.

Figure 6: NIM treatment effect over time (controlled for size and liquidity)



Notes: ROA is the dependent variable of the regression. The dots represent the value of coefficient ω_t of each, and the vertical line limits its confidence interval at the 95% level.

As presented through this section, the parallel trends assumption during the pre-pandemic period cannot be rejected for none of the dependent variables, even though some of the confidence intervals crossed the horizontal axis for a small margin. Nevertheless, the not rejection of the parallel trends assumption makes the results obtained in section 5.2 robust and consistent.

6. Conclusions and Limitation

In this section. the main conclusion and limitations resulting from this study will be presented.

6.1 Conclusion

This research examines the impact of the Covid-19 pandemic on the performance of European commercial banks, taking into consideration if they apply Internal Ratings-Based approach or Standard approach to determine risk weights and consequently the level of capital requirements. The data was retrieved from BankScope, European Banking Authority, Eurostat and European Central Bank, for a period of five years, from 2017 to 2021. The sample consist of 397 commercial banks, 70 of them under IRB approach in 2017. A number that increases to 73 in the next years.

As performance measures it was used Return on Assets, Return on Equity and Net Interest Margin. The estimation method employed was the Difference-in-Differences as it is used to examine the treatment effects of natural or quasi-natural events that cause changes in a specific group's environment. Diff-in-Diff studies treatment effects by examining the difference between differences in two groups rather than assessing differences in just one group.

The estimations revealed that the positive difference between IRB bank and SA bank's ROA from 2017 to 2020 (pre-pandemic period) is not statistically significant. The same is verified for ROE thus, the hypothesis one is rejected for this metrics. The hypothesis is also rejected when analyzing the NIM as SA banks had superior performance during that period. The deductions remained unchanged by introducing controls and fixed-effects.

Concerning the negative impact of the pandemic on banks under SA approach, the effect was only statistically significant for ROE and NIM. Hence, the hypothesis two is verified for ROE and NIM, while it is rejected for ROA regardless the addition of bank-level controls, macroeconomic-level controls, country fixed-effects, bank fixed-effects and year fixed-effects.

Finally, the hypothesis three is only accepted for NIM and just when controlled for bank-level variables, macroeconomic-level variables or country fixed-effects. Therefore, the IRB approach saved banks from additional losses compared to banks that apply SA approach.

The robustness checks consisted in examining if the parallel trends assumption between the ROA, ROE and NIM of the two bank groups in the period before the pandemic confirms. To perform the test, a non-parametric version of Diff-in-Diff was estimated. The results sustain the assumption and therefore the estimations would be considered consistent.

6.2 Limitations

The fundamental constraint of this study is the lack of available data. As a result, some robustness checks could not be conducted since they required more recent data, and the pandemic was a recent event. It would be interesting to update the sample in the future not just to have more data for the period during and after the pandemic, but also to perform stronger robustness checks (particularly treatment reversals).

Bibliography

Adam, M. H. M. (2014). Evaluating the Financial Performance of Banks Using Financial Ratios - A Case Study of Erbil Bank for Investment and Finance. *European Journal of Accounting Auditing and Finance Research*, *2*(6), 162–177.

Altman, E. I. (1968). Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *The Journal of Finance of Finance*, *23*(4), 589–609.

Bank for International Settlements (BIS) -website. Consulted in https://www.bis.org/

BCBS. (1988). International convergence of capital measurement and capital standards. *Bank for International Settlements,* Basel, Switzerland.

BCBS. (2004). Implementation of Basel II: Practical considerations. *Bank for International Settlements*, Basel, Switzerland.

BCBS. (2006). Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework - Comprehensive Version. *Bank for International Settlements,* Basel, Switzerland.

BCBS. (2009). Consultative Proposals to Strengthen the Resilience of the Banking Sector Announced by the Basel Committee. *Bank for International Settlements,* Basel, Switzerland.

BCBS. (2010). Basel III: A global regulatory framework for more resilient banks and banking systems. *Bank for International Settlements,* Basel, Switzerland.

BCBS. (2013). Regulatory consistency assessment programme (RCAP) - Analysis of risk-weighted assets for credit risk in the banking book. *Bank for International Settlements,* Basel, Switzerland.

BCBS. (2017). Basel III: Finalising post-crisis reforms. *Bank for International Settlements,* Basel, Switzerland.

Beaver, W. H. (1966). Financial Ratios as Predictors of Failure. *Journal of Accounting Research,* 4 (1966), 71-111.

Beck, T. (2020, August). How is coronavirus affecting the banking sector? Economics Observatory. Retrieved from https://www.economicsobservatory.com/how-coronavirus-affecting-banking-sector

Behn, M. , Haselmann, R., Vig, V. (2016b). The Limits of Model-based Regulation. *The Journal of Finance of Finance*, *77*(3), 1635–1684.

Behn, M., Haselmann, R., & Wachtel, P. (2016a). Procyclical capital regulation and lending. *The Journal of Finance of Finance*, *71*(2), 919–956.

Berger, A. N., Hanweck, G. A., & Humphrey, D. B. (1987). Competitive viability in banking: scale, scope, and product mix economies. *Journal of Monetary Economics,* 20 (3), 501–520.

Bhagwat, R., & Sharma, M. K. (2007). Performance measurement of supply chain management: A balanced scorecard approach. *Computers & Industrial Engineering*, 53(1), 43–62.

Borio, C. (2020, June). The prudential response to the Covid-19 crisis. BIS management speeches. Retrieved from https://www.bis.org/speeches/sp200630a.htm

Borroni, M., Piva, M., & Rossi, S. (2016). Determinants of Bank Profitability in the Euro Area: Has Anything Changed? DISCE - *Quaderni del Dipartimento di Scienze Economiche e Sociali*, Università Cattolica del Sacro Cuore, 119.

Bourke, P., (1989). Concentration and other determinants of bank profitability in Europe, North America and Australia. *Journal of Banking and Finance* 13 (1), 65–79.

Chadwick, L. (2020). Euronews. How COVID-19 upended life in Europe throughout 2020. Retrieved from https://www.euronews.com/2020/12/31/how-covid-19-upended-life-in-europe-throughout-2020

Cucinelli, D., Di Battista, M. L., Marchese, M., & Nieri, L. (2018). Credit risk in European banks: The bright side of the internal ratings based approach. *Journal of Banking and Finance*, 93 (2018), 213-229

Dagher, J., Dell'Ariccia, G., Laeven, L., Ratnovski, L., & Tong, H. (2020). Bank capital: a seawall approach. *International Journal of Central Banking*, 16 (2), 249-291.

Dietrich, A., & Wanzenried, G. (2011). Determinants of bank profitability before and during the crisis: Evidence from Switzerland. *Journal of International Financial Markets, Institutions and Money*, 21 (2011), 307–327.

European Banking Authority. (2013). Summary report on the comparability and pro-cyclicality of capital requirements under the Internal Ratings Based Approach in accordance with Article 502 of the Capital Requirements Regulation.

European Banking Authority. (2016). Cyclicality of capital requirements.

Ferri, G., & Pesic, V. (2017). Bank regulatory arbitrage via risk weighted assets dispersion. *Journal of Financial Stability*, 33 (2017), 331–345.

Financial Services Authority, 2010. Results of 2009 Hypothetical Portfolio Exercise for Sovereigns, Banks and Large Corporations.

Gropp, R., Hakenes, H., & Schnabel, I. (2011). Competition, risk-shifting, and public bail-out policies. *Review of Financial Studies*, 24 (6), 2084–2120.

Hakenes, H., & Schnabel, I. (2011). Bank size and risk-taking under Basel II. *Journal of Banking and Finance*, 35 (6), 1436-1449.

Hanley, C. A., & Suter, M. P. (1997). Banking's top performance. *ABA Banking Journal*, 89(7), 36–40.

Kaplan, R. S., & Norton, D. P. (1992). The Balanced Scorecard - Measures that drive performance. *Harvard Business Review*, 70(1), 71–79.

Kosmidou, K., Pasiouras, F., Doumpos, M., & Zopounidis, C. (2006). Assessing performance factors in the UK banking sector: A multicriteria methodology. *Central European Journal of Operations Research*, 14(1), 25–44.

KPMG, (2020). COVID-19: Impact on the banking sector. KPMG International. Retrieved from https://home.kpmg/xx/en/home/insights/2020/07/covid-19-impact-on-banking-m-and-a-2020.html

Lebas, M. J. (1995). Performance measurement and performance management. *International Journal of Production Economics*, 41(1), 23–35.

Liu, C. (2021). The IRB model, bank regulatory arbitrage, and the Eurozone crisis. *Journal of International Money and Finance*, 166.

Malovana, S., Kolcunová, D., & Brož, V. (2019). Does monetary policy influence banks' risk weights under the internal ratings-based approach? *Economic Systems*, 43 (2).

Mariathasan, M., & Merrouche, O. (2014). The manipulation of basel risk-weights. *Journal of Financial Intermediation,* 23 (3), 300–321.

Marques. B. & Alves. C. (2020). Using Clustering Ensemble to Identify Banking Business Models. Intelligent Systems in Accounting. Finance and Management. Vol. 27. No. 2. 66–94.

Martynova, N. (2015). Effect of bank capital requirements on economic growth: a survey. *De Nederlandsche Bank*, 467.

Merikas, A., Merika, A., Penikas, H., & Surkov, M. A. (2020). The Basel II internal ratings based (IRB) model and the transition impact on the listed Greek banks. *The Journal of Economic Asymmetries*, 22 (2020).

Micco, A., Panizza, U., & Yanez, M. (2007). Bank ownership and performance. Does politics matter? *Journal of Banking and Finance* 31 (1), 219–241.

Montes, C., Artigas, C., Cristófoli, M., & Segundo, N. (2018). The impact of the IRB approach on the risk weights of European banks. *Journal of Financial Stability*, 39 (2018), 147-166.

Nikolić, J., Nielsen, J., & Peković, J. (2022). Board Structure and Bank Performance: The Mediating Role of Intellectual Capital. *Naše Gospodarstvo/Our Economy*, 68(2), 28-42.

Pasiouras, F., & Kosmidou, K. (2007). Factors influencing the profitability of domestic and foreign commercial banks in the European Union. *Research in International Business and Finance*, 21(2), 222–237.

Peter, B. & Mihail, (2010). The management of credit risk according to internal ratings-based approach. *Annals of Faculty of Economics*, University of Oradea, 1 (2), 665-671.

Schiozer, R. F., Mourad, F. A., & Martins, T. C. (2021). A Tutorial on the Use of Differences-in-Differences in Management, Finance, and Accounting. *Revista de Administração Contemporânea*, 25. https://doi.org/10.1590/1982-7849rac2021200067

Schiozer, R., Mourad, F. A., & Vilarins, R. S. (2018). Bank risk, bank bailouts and sovereign capacity during a financial crisis: a cross-country analysis. *Journal of Credit Risk*, 14 (4), 1-28.

Short, B., (1979). The relation between commercial bank profit rates and banking concentration in Canada, Western Europe and Japan. *Journal of Banking and Finance*, 3 (3), 209–219.

Steward, R. (2021). Improving regulatory capital allocation: a case for the internal ratings-based approach for retail credit risk exposures. *Journal of Financial Regulation and Compliance,* 29 (3), 317-335

Wirnkar, A. D., & Tanko, M. (2008). CAMELs and Banks Performance Evaluation: The Way Forward. *SSRN Electronic Journal*, 1–21.

Wu, H.-Y. (2012). Constructing a strategy map for banking institutions with key performance indicators of the balanced scorecard. *Evaluation and Program Planning*, 35 (3), 303-320.