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Risk-Weighted Assets, Internal Ratings Based Approach and lending activity: evidence from European banks

Francisco Henrique de Azevedo e Gonçalves Vaz

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Professor Doutor Fábio Dias Duarte

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Resumo

Motivado pelo elevado número de choques económicos nos últimos anos foram implementados vários quadros regulatórios com o objetivo de aumentar a estabilidade e proteção do sector bancário. Um dos principais quadros regulatórios implementado foi Basel II, em 2004, que permite aos bancos usar uma nova metodologia para o cálculo dos requisitos de capital – a Internal Ratings Based Approach (IRBA). Este estudo tem o objetivo de analisar o impacto na atividade de concessão de crédito em resultado do recurso ao IRBA para o cálculo dos requisitos de capital. Este estudo contribui para três vertentes da literatura (a) relação entre a política monetária e o bank lending channel (b) a influência do IRBA no crédito bancário concedido (c) a associação do IRBA com a manipulação de requisitos de capital.

Usamos um modelo de efeitos aleatórios numa amostra em painel composta por 60 bancos entre os anos de 2016 e 2021 para estudar a relação entre Risk-Weighted Assets (RWAs) e o crédito bancário concedido. Adicionalmente, estudamos a relação entre o uso de IRBA e o crédito bancário concedido e o efeito da capitalização bancária na relação entre o IRBA e o crédito bancário concedido.

Em primeiro lugar, os resultados sugerem uma relação negativa entre requisitos de capital e o crédito total concedido, sugerindo que a política monetária é sentida através do bank lending channel. Em segundo lugar, não encontramos uma relação linear estatisticamente significativa entre o IRBA e o crédito total concedido sugerindo que não há manipulação de requisitos de capital. Em terceiro lugar, uma análise suplementar revela que a relação entre o uso de IRBA e o crédito total concedido segue a forma de U, sugerindo que a adoção de IRBA tem um efeito não linear no crédito total concedido. Por último, descobrimos que a capitalização não tem impacto na relação entre o IRBA e o crédito total concedido.

Abstract

Motivated by the high number of economic shocks in the recent years, several regulatory frameworks were implemented with the goal of increasing protection and stability to the banking sector. One of the main frameworks implemented was Basel II in 2004, which allowed banks the possibility to use a new methodology for their capital requirements calculation – the Internal Ratings Based Approach (IRBA). This study has the goal of studying the impact on lending activity resulting from the use of IRBA for the calculation of capital requirements. This research contributes for three existing strands of literature (a) the relationship between monetary policy and the bank lending channel (b) IRBA influence on bank lending (c) the association between IRBA with capital requirements manipulation.

We used a random effects model on panel data composed by 60 European banks between the years of 2016 and 2021 to study the relationship between RWAs and bank lending. Furthermore, we study the relationship between IRBA and bank lending and the capitalization effect on the relationship between IRBA and bank lending.

Firstly, results suggest a negative relationship between capital requirements and bank lending suggesting that monetary policy is felt through the bank lending channel. Secondly, we did not found a significant linear relationship between IRBA and bank lending suggesting that there is no capital requirements manipulation. Thirdly, a supplementary analysis reveals the relationship between IRBA and bank lending follows a U shape, suggesting that IRBA adoption has a non-linear effect on bank lending. Lastly, we found that capitalization has no impact on the IRBA and bank lending relationship.

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1. Introduction

The impact of financial crisis in the world economy soared interest for international institutions to investigate and regulate capital with the aim of maintaining banking sector more protected and stable. Over the last 40 years, the bank for international statements (BIS), published a number of regulatory frameworks that impacted, among others, capital requirements and disclosure requirements (BIS, 2004; BIS 2014).

Central bank controls monetary policy by imposing several capital requirements. As defined by Kashyap et al. (2004), capital requirements have the goal to diminish default costs. On one side, an increase in capital can be associated with an increase protection against shocks. On other side, capital requirements may negatively impact credit-creation and liquidity-creation. The impact of capital requirements on lending channel is motivated by these conceptual trade-offs.

In 2004, the Basel Capital Accord II (Basel II, hereafter) introduced changes in the calculation of capital requirements[1]. On the new ruling, banks were allowed to compute their risk weighted assets (RWA) by one of two different approaches– the standard approach (SA – a flat risk weight approach), or the internal-rating-approaches (IRBA – a flexible risk weigh approach based on own credit risk assessment). By opting to implement the IRBA approach, it would be expected that banks take several steps to implement this approach for all loan portfolio over-time (Behn et al., 2022). However, because of the demanding criteria, it is common for banks to apply IRBA to only part of their asset classes (BIS, 2001). This is particularly common on large and diversified banks with their operations dispersed over several locations. Still, the ability to use this approach should contribute for better risk assessment. Furthermore, it allows bank to use their internal measures, including private information on clients' creditworthiness, to assess the risk and compute favourable risk weighted assets. As a result, banks utilizing IRBA may experience a reduction in capital requirements– the so-called *internal information hypothesis* (Cucinelli et al., 2018; Merikas et al., 2020; Bikker et al., 2002). Although the flexibility that this approach gives to banks, IRBA implementation requires a substantial initial investment in risk management systems (Hakenes et al., 2011). Because only banks of a particular size can afford this additional fixed cost, IRBA is mostly used by larger banks, giving them a competitive edge (Drumond, 2009; Hakenes et al., 2011). Moreover, abuse of IRBA methodology has also been found, as certain

[1] See BIS (2014) for additional information

banks benefit from a reduction in regulatory requirements despite maintaining the same level of risk (Behn et al., 2022; Mariathasan et al., 2014; Jones, 2000) - the so-called "*regulatory capital arbitrage hypothesis*".

Basel III was introduced in the wake of the financial crisis that lasted from 2007 to 2009, changing capital requirements framework (BIS, 2011). First off, even if the amounts of capital requirements stayed the same, the type of capital that must be retained changed. With Basel III, capital must have a greater proportion of high-quality capital (CET1 and Tier1 capital) in order to satisfy the capital criterion. Moreover, Basel III introduced a countercyclical buffer. National authorities would use this buffer when they felt that loan expansion had reached a level where a downturn would negatively affect the economy. In order to provide shock protection, a conservation buffer was lastly implemented, which consisted of demanding more high-quality capital from banks outside of times of stress.

In 2017, the final-stage of Basel III – the so called "Basel IV" - was published. On this framework several changes are planned to be implemented starting from 1st January 2022 until 1st January 2027 (BIS, 2017). Changes to both SA and IRBA are planned, with the objective of diminishing excess variability of RWAs between banks (e Santos et al., 2020), thus looking to contribute for the restoration of credibility on the calculation of RWAs, namely by correcting some problems that resulted from the miss usage of IRBA. On SA, a more detailed risk weighting approach was allowed to be used instead of a flat risk weight. For IRBA new constrains were added for some exposures classes (e.g., *banks* and *corporates*) regarding the number of parameters that banks could estimate by themselves. Additionally, within the same bank, it was required that the amount of RWAs when IRBA was used could not be lower than a pre-determined floor. To find the floor, the exposures were calculated using SA. Then, these exposures would be multiplied by weighting factor imposed by the regulatory framework. If the RWA calculated from IRBA is lower than the floor computed by the SA, the floor value is used to compute the RWA. This measure had the goal of limiting bank's competitive advantages arising from extensive usage of internal rating models.

In this new regulatory framework, it is crucial to comprehend how does Basel Capital Accords and monetary policy influence the bank lending channel. This topic has been a significant subject in banking literature for a long time. Bernanke and Blinder's (1988) were one the first contributors to this field by examining how monetary policy impacts bank loans other than demand deposits. On recent years, a wide pool of literature documented the transmission of monetary policy was felt through the lending channel on emerging countries

(e.g., Le et al. 2022). However, for the European context, this transmission, despite present, was less noticeable (Grandi 2019, Brisimis et al., 2009, Altumbas et al., 2002). Due to the scarcity of research during the recent years detailing the effect on the lending channel on a sample of the European Union, as well as the beginning of the Basel IV implementation, examining the impacts of risk assessment approaches on lending activity has gained further significance. Our study is guided by this open research avenue. Particularly, in this research we seek to answer the following research question: *how does the adoption of IRBA methodology effect lending activity [the lending channel]*? By examining how adopting SA and IRBA impact bank lending, we extend the knowledge on lending channel within the European Union context, whose economies are essentially driven by the banking system.

To answer our research question, we examine a sample of 60 European banks for a period of 6 years including banks using both IRBA and SA with the goal of testing the impact of IRBA and RWA on lending activity and the effect of capitalization on the relationship between IRBA and lending. Using a panel data random effects model, we show evidence that capital requirements (CR), proxied by RWAs, are negatively associated with the bank lending growth. We also found evidence on a non-linear U-shaped relationship between IRBA and bank lending growth. Finally, we also reveal that capitalization effect on the relationship between IRBA and lending is not statistically significant.

This study offers three main contributions. Firstly, by determining if capital requirements impact lending, this study contributes for the literature on lending channel on the EU context (e.g., Grandi 2019, Brisimis et al., 2009 and Altunbas et al., 2002). Secondly, by analysing the impact IRBA on lending, we are able to determine if banks are using IRBA to underreport RWAs. Thus, we contribute to literature regarding banks' RWA underreporting (e.g., Behn et al., 2022 and Mariathasan et al., 2014). Finally, by analysing the effect of IRBA on lending we are able to access the difficulties that newer banks have when adopting IRBA contributing for future policy makers decisions.

The remainder of this paper is organized as follows. In section 2, we present our literature review and the research hypotheses. In Section 3, we present our data and variables. Section 4 describes the method. Empirical findings are reported in Section 5. In Section 6 we conclude and discuss our main findings according to the previous research.

2. Literature Review and research hypotheses

2.1. The Banking lending channel

Bernanke and Blinder (1988) offered the first contribution for the study of lending channel. The authors added a novel perspective to earlier theoretical framework where monetary policy changes would only be felt by the bank's capacity to issue demand deposits. In the earlier view, in case of more stringent liability reserve requirements, banks would simply switch from transaction deposits to certificate of deposits, not impacting the bank's assets. However, according to Bernanke and Blinder (1988) this perfect substitution it's not possible, leading to monetary policy changes to be felt through the supply of credit.

Banks have an information advantage that allows to fund clients which otherwise could not easily substitute bank credit for other sources of capital on open markets (Bernanke et al., 1990). Consequently, in case of an economic and monetary shocks impacting banks liquidity these clients would not have access to other sources of funding. This would lead to borrowing constraints because banks cannot frictionless shift the source of funding (Kashyap et al., 1995). Consequently, some businesses will cut their investment spending because they cannot fully replace bank credit. Despite the growing popularity of this view on the economic transmission effects from banks to clients, some authors argue that funding substitution for banks could happen, preventing the monetary transmission from being felt through the bank lending channel (Romer et al., 1990). Support for the lending channel, though, remained growing. The smaller a bank is, the more restricted should the access to capital sources be. As a result, Kashyap et al. (1995) hypothesized that smaller banks should experience increased difficulties in obtaining substitutes for funding in the event of a monetary tightening (since financial markets would not be a viable option). Thus, the size of the bank has a significant role in determining how strong the lending channel is. Furthermore, Kashyap et al. (2000) found that less liquid banks experience stronger transmission effects along the bank lending channel.

Up to this point, we have concentrated on literature from the US. But the banking sector on the different European nations is very different, resulting in the emergence on a new strand of literature. As was already mentioned, it's critical to consider the availability of alternative funding, bank size, and bank liquidity when assessing monetary policy transmission effects on banking lending channel. Hence, the transmission of monetary policy through the lending channel on European countries is anticipated to be weaker on countries with stronger banking systems and less bank-dependent firms (Kashyap et al., 1997).

Additionally, smaller and worse credit rated banks in a country should find it harder to replace funds, which would make lending channel stronger (Kasyap et al., 1997). Favero et al. (1999), however, found little proof for the existence of a lending channel or European countries. In contrast, Altumbas et al. (2002) discovered evidence of a lending channel in nations that are members of the European Union, adding that banks with lower capital would have a stronger lending channel. Furthermore, Gambacorta (2005) found (using an Italian sample) both the presence of a lending channel and that lending channel is stronger on less capitalized banks. However, is results also suggest banks size is not relevant on the bank lending channel.

In the years that followed, numerous studies confirmed the existence of the lending channel as a means of transmitting monetary policy. Altumbas et al. (2009) found that the use of securitization lead to weaker lending channel. Still following this line of thought, Gambacorta et al. (2011) used an international sample to demonstrate the existence of a lending channel, pointing out that developments in the securitization markets affect not only the lending channel but also the effects of capitalization, size, and liquidity on the lending channel. Finally, Jimenez et al. (2020) documented how the use of securitization can increase bank lending maintaining the same amount of risk.

Varghese (2018) found that the liquidity effect on the banking lending channel is decreasing over time (using a U.S. sample). Furthermore, Leroy (2014) uses a European sample to document the importance of size, liquidity and capitalization on the lending channel. Additionally, the author still adds the market power effect to the bank lending channel where the more competitive a bank is, the less it's the lending channel felt through it. Finally, Grandi (2019) and Heryan et al. (2017) documented the existence of heterogeneous lending channel effects within EU market and European Monetary Union, respectively[2]. Hence, examining how the monetary policy is felt through the lending channel is a topic that needs constant analysis. We intend to add to the banking lending literature by not only by examining if the lending channel exists inside the EU in the aftermath of the Basel III but also by looking particularly at the effect of IRBA on the bank lending channel.

[2] Mixed effects of monetary policy transmission have also been reported by literature on emerging and less developed countries (e.g., Sanfilippo-Azofra et al., 2018; Nguyen et al., 2022, Gnahe et al., 2022)

2.2. Capital requirements

The amount of capital a bank's hold depends on a variety of reasons. One explanation derives from the different cost of capital debt and equity. Interest payments are tax deductible and dividends are not (Fama et al.,2005). Hence, financial institutions would benefit from being mainly financed by debt. However, being mainly financed by debt would lead to an increase of risk potentially leading to higher bankruptcy and liquidation costs on distress periods (Fama et al.,2005).

A second explanation that encourages banks to hold capital is agency disputes between shareholders and debtholders (Jensen et al., 1976). Conflicts may arise as a result of information gaps between the various parties, which could prompt shareholders to try and restructure the bank's operations for their own gain. Additionally, even when a bank is doing well, shareholders are less inclined to commit new funds to the enterprise. Moreover, shareholders may attempt to persuade the bank to carry on its business after the point at which it should be liquidated (Jensen et al., 1976). Consequently, due to this behaviour from shareholders, debtholders may require higher interests rate. So, banks may increase their capital to signal debtholders bank's safety leading to stakeholder's interest alignment and avoiding increases on the cost of debt (Berger et al.,1995).

On a different view, governments have number of measures that protects the health of banking sector impacting the amount of capital bank's hold. For example, deposit insurances protect depositors in a case of a default. This type of measures negatively influences the amount of capital bank's need to hold by leading banks to reduce market discipline (Berger et al.,1995). Consequently, to alleviate frictions arising from market discipline avoidance, to protect from economic shocks, and to elude agency disputes, regulators found the need to impose capital requirements (Berger et al.,1995).

One of the imposed capital frameworks comes from the implementation of the Basel accords. Basel capital accords influences monetary policy and establish regulation and supervision criteria that banks must comply, namely at capital requirements level. It is expected that an increase of capital requirements (CR), which are an element of monetary policy, influence the lending activity. On this framework, the amount of capital that banks need to hold due to capital requirements is dependent on RWAs. To determine RWAs, the bank's assets are divided into multiple classes, and each class's risk weight is then multiplied by the correspondent exposure (for more details see Beltratti et al., 2016). Basing requirement

on RWAs instead of normal assets allows for a better risk assessment because different assets have different risk profiles (BIS, 1988).

Literature suggests that higher capital ratios not forced by requirements are positively associated with lending growth (Cohen et al., 2016 and Imbierowicz et al. 2021). The effect of an increase of capital requirements on lending channel is however a puzzle. The first strand of literature argues that an increase of CR can increase bank lending (Bahaj et al.,2020, Auer et al.,2022). While Auer et al. (2022) employed a Swiss sample to suggest that increased capital requirements (via countercyclical buffer) boost both lending and lending costs for banks, Bahaj et al. (2020) claims that the forced safety effect was the reason for the positive association between CR and lending activity. However, the second strand of literature argues that an increase on CR leads to a decrease in lending activity (e.g., Bridges et al., 2014 – UK; Fraisse et al., 2019 – France; Imbierowics et al., 2021 – Germany; Gropp et al., 2019 – Europe; Noss et al., 2016 – UK; Thakor, 1996 – US; Favara et al., 2021 – US) even if minimal (e.g., De Jonghe et al., 2020; Berrospide et al., 2010; Bikker et al., 2002).

The relationship between CR and lending activity might be influenced by bank's size (Ayar et al., 2016; Bridges et al., 2014), bank's liquidity (Thornton et al., 2020), capitalization (Bichsel et al., 2022; Gambacorta et al., 2018; Cohen et al 2016) and the amount of its capital buffer (Bridges et al., 2014). Moroever, Cohen et al. (2016) and Naceur et al. (2018) found that whereas capital ratios are associated with increasing lending in American banks, the reverse relationship is observed for European banks. This result might be attributed to the different systems acting on Europe and America.

The economic and financial systems in U.S./U.K./Switzerland can be considered market-based, where capital markets have an extra relevance (Levine, 2002). In this context, the extra access to capital markets is advantageous for both capital access and to avoid bank's control over the economy. For the remaining European Union countries, financial system can be considered bank-based which allows for banks to have superior information on client's creditworthiness allowing easier mobilization of funds to smaller companies (Levine, 2002). When compared to market based systems, bank-based systems are more prompt to misallocation of banking credit due to changes on assets' value (Langfield et al., 2016) Consequently, we might expect that more bank-based oriented economies should be more susceptive to macroeconomic changes (which can include regulatory changes). Hence, because our sample is based on European bank-based economies, we thus expect that an

increase of CR (proxied by RWA) will have a negative effect on with lending activity. Formally, we test the following hypothesis:

H1: *An increase in RWA will have a negative effect on the bank lending.*

2.3. IRBA and capital requirements

Basel II implementation allowed banks to calculate their RWAs based on 2 different methodologies (i) the standard approach (SA) where external ratings were used for each exposure class and (ii) the internal-rating based approach (IRBA) where the parameters for this calculation were provided by the bank. For the determination of RWAs through IRBA, banks must compute the following parameters: the probability of default (PD), the exposure at defaults (EAD) the loans maturity and the loss given default (LGD). Extra flexibility on the methodology choice leads to bank being able to change their ratios of capital. Thus, to comply with regulatory requirements, banks would also have the option to reduce their required amounts besides the option to increase their capital.

Basel II goal was not lower the minimum capital. The goal was for banks to utilize their own internal data to make risk weight computations as internal approaches tend to be more accurate to reality – the internal information hypothesis (Beltratti et al., 2016). In line with the internal information hypothesis, the use of IRBA allows banks to use their own estimates, benefiting from private information from their clients which would motivate large and systemically important banks to improve risk alignment (Barakova et al., 2014). Indeed, there is evidence suggesting that IRBA adoption is contributing for a better assessment of risk and stronger risk management practices by banks (Cucinelli et al., 2018). However, the flexibility of IRB approaches would allow for differences in risk weights due to a number of different causes not predicted by the regulatory framework which might include variations on bank modelling, differences on credit risk management practices, data quality, conservatism, and regulatory descriptions (Barakova et al., 2014).

One of the characteristics that distinguishes IRBA from the SA is its dependence on the economic cycle, which results in changes in capital requirements. While SA loans required capital is calculated when the loan is granted and kept constant until maturity, IRBA loans are continuously estimated and fluctuate in accordance to the economic cycle (Behn et al., 2016). Furthermore, the PD parameter of IRBA is more dependent on credit shocks than on actual default rates (Behn et al., 2016, Behn et al., 2022). This behaviour supports the procyclicality concept of capital regulation, which states that the usage of IRBA leads to a

rise of bank capital requirements during economic shocks and fall during boom times (Heid, 2007; Kashyap, 2004; Drummond, 2009).

Nevertheless, banks occasionally act in ways that aim to reduce the RWAs in order to meet capital requirements (Mariathasan et al., 2014; Barucci et al., 2018). The new approaches allow banks to use internal estimations rather than externally confirmed elements increasing the potential of risk arbitrage. (Benink et al., 2008). Thus, banks are compelled to underreport risk because they are aware that disclosing greater RWAs would result in higher capital requirements (Blum et al. 2008). This behaviour becomes more likely to occur in the absence of regulatory checks (Blum et al., 2008). Berg et al. (2017) studied the model risk of using IRB methodologies founding a large variation on probability of default computations (one of the parameters used for IRB methodology calculation) between banks. This evidence thus suggests some free-riding problems and regulatory arbitrage associated with underreporting of risk.

This effect is mentioned in multiple studies. For example, Huizinga et al. (2012) suggest that banks were not actively fully adjusting book value of mortgage-based assets to meet capital requirements. Acharia et al. (2013) suggest that commercial banks rely on securitization with the goal of underreporting lower risk thus reducing the amount of capital needed to comply with capital ratios required. Mariathasan et al. (2014) suggests that undercapitalized banks are more prone to engage on regulatory arbitrage through IRBA. Beltrati et al. (2016) suggest that banks with higher cost of equity would prefer a higher use of IRBA to reduce the amount of capital they should hold to meet Basel capital requirements. Montes (2018) also suggests the use of IRBA models allows to compute favourable capital ratios. Last but not least, Liu et al. (2021) discovered evidence pointing to the presence of RWA manipulation on Europe, especially on peripheral nations.

Regarding IRBA adoption and lending, Merikas et al. (2020) uses a Greek sample to provide evidence that IRBA adoption may not contribute for lending growth. Additionally, Andersen et al. (2020) does not find strong evidence that IRBA adoption contributes for long-term lending growth. However, a strand of literature argues a positive relationship between IRBA and lending, except on economic shock scenarios. Behn et al. (2022) uses a German sample to study differences between banks capital requirements with both SA and IRBA. The author found that banks using IRBA by having less stringent capital requirements would consistently underreport risk being this effect stronger for smaller and less capitalized

banks. Finally, banks using IRBA were successful in decreasing their capital requirements and increasing bank lending.

Following this strand of research, we hypothesize that:

H2: *An increase of the IRBA-to-SA ratio will have a positive effect on the banking lending.*

As defined in section 2.2, holding extra capital holds a number of advantages for banks. There is a motivation from banks, besides the stability associated with higher capital requirements, to have higher capital ratios. Strong capital ratios also play a signalling effect to the market. Banks get their funds for lending from borrowers. Consequently, having a higher capital sends a wealthy signal to borrowers (Gambacorta et al., 2018). Moreover, having free capital allows for bank to increase lending without increasing capital costs (Gambacorta et al., 2018). Additionally, having extra capital available allow for banks to react differently on the case on an increase on requirements (Berrospide et al., 2010). Banks who are very close to the requirements would actively need to diminish their assets (including lending) in the case of monetary tightening. However, for well capitalized banks, assets would not be impacted (Berrospide et al.,2010). Similarly, Bischel et al., (2022) documented that banks would not need any immediate action in the case of capital requirements tightening in the case their capitalization was above the requirement. As a result, according to Cohen et al. (2016), Gambacorta et al. (2018) and Bichsel et al. (2022), banks with larger capitalization are less exposed to monetary tightening. Behn et al. (2016) provide an additional examination of this point of view and suggest that banks with greater capital ratios are less likely to experience a decrease on loans during a financial crisis. Furthermore, Imbierowics et al. (2021), uncovered that adjustments to capital requirements would have an increase effect on loans made from banks with less capital.

Consequently, even though banks typically anticipate an increase in lending when they grow their IRBA portfolio, according to this line of reasoning, more capitalized banks are already less susceptible to changes in lending when additional regulations are put in place (Berrospide et al., 2010; Bichsel et al., 2022). As a result, it is anticipated that the benefits of implementing IRBA will not be as great for more capitalized banks. Thus, we formulate the following hypothesis:

H3: *The positive effect of the IRBA-to-SA ratio on banking lending is less effective for better capitalized banks.*

3. Data and Variables

3.1. Data

We collected annually data from Bank's regulatory disclosure reports containing information from 60 banks (all G-SIBs [3]or O-SIBSs[4]), from 19 different European countries and from the year 2016 to 2021. According to the 3rd pillar of Basel capital requirements, banks are required to provide information about key metrics to market participators[5]. The information required includes both the total amount of RWAs and the amount calculated using each exposure type (IRBA or SA). To measure bank's capitalization and for controls purpose we collect data from BankFocus and the World Development Indicators (WDI) databases. We drop observations with missing values in at least one of our independent variables. Furthermore, to decrease our exposure to outliers, we dropped observation bellow the 1% percentile and above the 99% percentile for our dependant variable.

Table 1 shows the composition of our sample. Panel A displays information about sample distribution by year. Panel B breakdown our observations by country. Germany (15,64%), France (10,75%), Spain (8,79%), Netherlands (8,14%) and Belgium (7,82%), account for the countries with most observations, while Slovakia (0,65%), Finland (0,98%) and Cyprus (1,3%) account for the nations with less observations. Panel C displays the banks in our sample. Most banks have between 4 to 6 observations along the 6-years' time horizon (2016-2021). Table 2 displays the observations by country and year.

[3] Global Systemically Important Banks
[4] Other Systemically Important Institutions
[5] see BIS (2015) for additional information

Table 1. Sample composition

Panel A: Year		**#Obs**	**Perc.**
	2016	36	11.73
	2017	48	15.64
	2018	56	18.24
	2019	57	18.57
	2020	55	17.92
	2021	55	17.92
	Total	**307**	**100**
Panel B: Country		**#Obs**	**Perc.**
	Austria	12	3.91
	Belgium	24	7.82
	Cyprus	4	1.30
	Estonia	15	4.89
	Finland	3	0.98
	France	33	10.75
	Germany	48	15.64
	Greece	17	5.54
	Ireland	8	2.61
	Italy	22	7.17
	Latvia	11	3.58
	Lituania	12	3.91
	Luxembourg	11	3.58
	Malta	9	2.93
	Netherlands	25	8.14
	Portugal	14	4.56
	Slovakia	2	0.65
	Slovenia	10	3.26
	Spain	27	8.79
	Total	**307**	**100**
Panel C: Bank		**#Obs**	**Perc.**
	AB SEB BANKAS	6	1.95
	ABN AMRO GROUP N.V.	2	0.65
	ALPHA SERVICES AND HOLDINGS SOCIETE ANO	5	1.63
	ARGENTA SPAARBANK	6	1.95
	AS "SEB BANKA	6	1.95
	AS SEB PANK	6	1.95
	AXA BANK BELGIUM	6	1.95
	BANCA MONTE DEI PASCHI DI SIENA SPA	5	1.63
	BANCO BILBAO VIZCAYA ARGENTARIA SA	6	1.95
	BANCO BPM SPA	5	1.63
	BANCO COMERCIAL PORTUGUES. SA	6	1.95
	BANCO DE SABADELL SA	6	1.95
	BANCO SANTANDER SA	6	1.95
	BANK OF CYPRUS HOLDINGS PUBLIC LIMITED	4	1.30
	BANK OF IRELAND GROUP PLC	4	1.30
	BANK OF VALLETTA PLC	5	1.63
	BANQUE ET CAISSE D'EPARGNE DE L'ETAT LU	5	1.63
	BANQUE INTERNATIONALE A LUXEMBOURG SA	6	1.95
	BAYERISCHE LANDESBANK	5	1.63
	BELFIUS BANQUE SA/NV	6	1.95
	BFA TENEDORA DE ACCIONES SAU	4	1.30
	BNG BANK N.V.	6	1.95
	BNP PARIBAS	5	1.63
	BPCE SA	6	1.95

CAIXA GERAL DE DEPOSITOS	5	1.63
CAIXABANK. S.A.	5	1.63
COMMERZBANK AG	5	1.63
COOPERATIEVE RABOBANK U.A.	5	1.63
CREDIT AGRICOLE SA	6	1.95
CREDIT MUTUEL (COMBINED - IFRS)	4	1.30
DE VOLKSBANK N.V.	6	1.95
DEKABANK DEUTSCHE GIROZENTRALE	6	1.95
DEUTSCHE BANK AG	6	1.95
DZ BANK AG DEUTSCHE ZENTRAL-GENOSSENSCH	6	1.95
ERSTE GROUP BANK AG	6	1.95
EUROBANK ERGASIAS SERVICES AND HOLDINGS	6	1.95
HAMBURG COMMERCIAL BANK AG	5	1.63
HSBC BANK MALTA PLC	4	1.30
ING GROEP NV	6	1.95
INTESA SANPAOLO	6	1.95
KBC GROEP NV/ KBC GROUPE SA	6	1.95
LA BANQUE POSTALE	6	1.95
LANDESBANK BADEN-WUERTTEMBERG	5	1.63
LANDESBANK HESSEN-THUERINGEN GIROZENTRA	5	1.63
LUMINOR BANK AS	3	0.98
MUNICIPALITY FINANCE PLC	3	0.98
NATIONAL BANK OF GREECE SA	5	1.63
NORDDEUTSCHE LANDESBANK - GIROZENTRALE	5	1.63
NOVA KREDITNA BANKA MARIBOR D.D.	5	1.63
NOVA LJUBLJANSKA BANKA D.D.	5	1.63
NOVO BANCO	3	0.98
PIRAEUS BANK SOCIETE ANONYME	1	0.33
RAIFFEISEN BANK INTERNATIONAL AG	6	1.95
SOCIETE GENERALE	6	1.95
SWEDBANK AB	6	1.95
SWEDBANK AS	5	1.63
SWEDBANK AS EE	6	1.95
ULSTER BANK IRELAND DAC	4	1.30
UNICREDIT SPA	6	1.95
VSEOBECNA UVEROVA BANKA A.S.	2	0.65
Total	**307**	**100**

Table 2. Sample composition by country and year

Country	2016	2017	2018	2019	2020	2021	Total
Austria	2	2	2	2	2	2	**12**
Belgium	4	4	4	4	4	4	**24**
Cyprus	0	0	1	1	1	1	**4**
Estonia	2	2	2	3	3	3	**15**
Finland	0	0	0	1	1	1	**3**
France	5	4	6	6	6	6	**33**
Germany	4	8	9	9	9	9	**48**
Greece	1	3	3	3	3	4	**17**
Ireland	0	1	2	2	2	1	**8**
Italy	2	4	4	4	4	4	**22**
Latvia	2	2	2	2	2	1	**11**
Lituania	2	2	2	2	2	2	**12**
Luxembourg	1	2	2	2	2	2	**11**
Malta	1	0	2	2	2	2	**9**
Netherlands	3	5	5	4	4	4	**25**
Portugal	1	3	3	3	2	2	**14**
Slovakia	0	0	0	0	1	1	**2**
Slovenia	1	2	2	2	1	2	**10**
Spain	5	4	5	5	4	4	**27**
Total	**36**	**48**	**56**	**57**	**55**	**55**	**307**

3.2. Variables

Table 3 displays variables definition.

Table 3. Variables Definition

Variable	Measure	Description	Source
Dependent variable			
Net Loan Growth	%	The annual variation of net loans (in percentage)	BankFocus
Independent Variables			
RWA	Ratio	The amount of RWAs divided by (book value) total assets	Bank's Disclosure Reports
IRBA	Ratio	The amount of Credit risk exposures computed by IRBA divided by all credit risk exposures (assumes the value 0 for if computed exclusively by SA and value 1 if exclusively by IRBA)	Bank's Disclosure Reports
Capitalization	Ratio	The total amount of book value of equity divided by total assets	BankFocus
Control Variables			
Bank characteristics			
Total Assets	Million €	Total amount of balance sheet total assets (in million)	BankFocus
Capital Adequacy	Ratio	The amounts of capital tier 1 and capital tier 2 divided by RWAs	BankFocus
Return on Average Assets	Ratio	The Net income divided by average total assets (Average total assets is calculated by (previous period total assets + current period total assets)/ 2)	BankFocus
Last	Ratio	The ratio between book value of liquid assets divided to short-term funding + total deposits	BankFocus
Overhead	Ratio	The amount of overhead expenses divided by total assets	BankFocus
Cash	Ratio	The amount of cash and balances at central bank divided by total assets	BankFocus
NPL	Ratio	The non-performing and impaired loans divided by total assets	BankFocus
Macroeconomic characteristics			
GDP growth	%	Annual variation of GDP (in percentage)	World Development Indicators (WDI)
Credit to private	%	Annual variation of financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable (as a percentage of GDP)	World Development Indicators (WDI)
Euribor	%	The 12-month Euro InterBank Offered Rate	Euribor-rates.eu

3.2.1. Dependent variable

Consistent with research in the field (e.g. Hu et al., 2019; Nguyen et al., 2022), we use the annual increase of net loans (in percentage) as our dependent variable to measure effects on lending channel.

3.2.2. Independent variables

We use three key independent variables. First, the IRBA ratio (as described by Montes et al., 2018) to look how the methodology's choice impacts lending. IRBA is the ratio defined by the amount of RWA computed by IRBA divided by the total RWA (which contains IRBA + SA). Second, we use the RWA density to examine the effect of RWAs on lending (Beltratti et al., 2016). RWA density enables bank comparisons and is calculated as the ratio of a bank's RWAs to its total assets. Finally, to examine the capitalization effect on the relationship between IRBA and lending, we rely on the variable Capitalization that is the ratio of book value of equity over total assets (similarly to Hu et al., 2019).

3.2.3. Control variables

To control for bank heterogeneity, we used proxies for CAMELS rating (criteria used by regulators to evaluate banks) as defined by Berger et al. (2019). This rating as several different components. We use the Capital Adequacy ratio as a proxy for *Capital Adequacy,* the Non-performing and impaired loans/TotalAssets for *Asset quality*, OverheadExpenses/TotalAssets for *Management quality*, Return on Average Assets for *Earnings*, Cash and Balances on Central Bank/TotalAssets for *Liquidity* and the ratio between balance sheet liquid assets divided by deposits and short term-funding for *Market risk*. To control for country heterogeneity, we use the variables Growth rate of GDP and Credit to Private Sector obtained from Work Development Indicators (WDI) (Hu et al., 2019). Finally, to control for the yearly variation of availability of funding to banks we use the 12month-Euribor.

3.3. Descriptive statistics

The descriptive statistics for our variables are displayed on Table 4. 307 year-bank observations form the basis for the statistics. Regarding our dependent variable, the net loan growth increase, on average, 2,632% a year. Regarding our explanatory variables, RWA is on average 37,6% of total assets. More than 60% of RWAs is computed using IRBA. The Capitalization ratio (=Equity/Total Assets) is on average 7.4%. Table 5 reports the

correlation matrix. High pair correlation values are not found, ruling out issues with multicollinearity.

Table 4. Descriptive Statistics

Variable	Measure	#Obs.	Mean.	Std.Dev.	Min.	Max.
Dependent variable						
Net Loan Growth	%	307	2.632	8.105	-25.206	45.352
Independent Variables						
RWA	Ratio	307	0.376	0.135	0	0.807
IRBA	Ratio	307	0.604	0.323	0	1
Capitalization	Ratio	307	0.074	0.032	0.022	0.212
Control Variables						
Bank characteristics						
Total Assets	Million €	307	356379.2	515215.3	3518.738	2634444
Capital Adequacy	Ratio	307	0.214	0.116	0.117	1.327
Return on Average Assets	Ratio	307	0.399	0.691	-4.053	1.981
Last	Ratio	307	50.495	40.762	9.373	303.945
Overhead	Ratio	307	0.014	0.005	0.001	0.029
Cash	Ratio	307	19.712	31.276	1.949	413.447
NPL	Ratio	307	0.035	0.064	0	0.479
Macroeconomic characteristics						
GDP growth	%	307	0.041	0.046	-0.082	0.186
Credit to private	%	307	82.26	22.82	27.86	136.069
Euribor	%	307	-0.002	0.002	-0.005	0.001

Table 5. Correlation Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Dependent variable															
Net Loan Growth	**1**	1.0000													
Independent Variables															
RWA	**2**	-0.2281	1.0000												
IRBA	**3**	0.0339	-0.2288	1.0000											
Capitalization	**4**	-0.0471	0.6260	-0.0612	1.0000										
Control Variables															
Bank characteristics															
Total Assets	**5**	-0.0080	-0.2461	0.0779	-0.3775	1.0000									
Capital Adequacy	**6**	0.0810	-0.4071	-0.0627	0.0726	-0.1876	1.0000								
Return on Average Assets	**7**	0.3497	-0.0182	0.0938	0.3557	-0.1342	0.1628	1.0000							
Last	**8**	0.0658	-0.3537	-0.1393	-0.3843	0.2975	0.1738	-0.0618	1.0000						
Overhead	**9**	-0.0712	0.6606	-0.2555	0.3985	-0.0174	-0.4088	-0.0706	-0.3222	1.0000					
Cash	**10**	0.0101	-0.1280	-0.1235	-0.1130	-0.0308	-0.0046	-0.1079	0.2129	-0.0868	1.0000				
NPL	**11**	-0.2769	0.5717	-0.2984	0.3387	-0.1256	-0.1828	-0.2669	-0.2132	0.3719	0.0935	1.0000			
Macroeconomic characteristics															
GDP growth	**12**	0.1606	0.0007	-0.0093	0.2147	-0.1644	0.0786	0.2519	-0.0744	-0.0350	-0.1132	-0.1686	1.0000		
Credit to private	**13**	-0.1673	-0.1812	-0.1720	-0.4741	0.4308	-0.0539	-0.3240	0.2148	-0.1107	0.1300	0.0736	-0.3114	1.0000	
Euribor	**14**	-0.0497	0.1053	0.0950	0.0948	-0.0016	-0.0515	0.0410	-0.0238	0.1520	0.1893	0.1479	-0.3791	0.0158	1.0000

4. Method

We use several estimation methods to ensure that we selected the model that better fits with our panel data (with longitudinal observations) thus increasing the robustness of our findings (Ba et al., 2021). First, we applied for fixed effects model, assuming that some model parameters are non-random. For example, the bank's loan growth can be influenced by unobserved commercial ability and strategic governance policies or by non-random institutional factors affecting each bank in a given country. As opposed to Random effects (RE) model, Fixed effects (FE) model assume that the group means are non-random (Ba et al., 2021). Thus, we started by estimating the following FE model:

$$NLG_{itc}=\beta_0 + \beta_1 RWA_{it} + \beta_2 IRBA_{it} + \beta_3 Capitalization_{it} + \beta_4 (IRBA_{it} \times Capitalization_{it}) + \sum_{k=1}^{7} \gamma_k CAMELS_{k,it} + \sum_{n=1}^{3} \theta_n Macroeconomic_{tc} + \alpha_i + \mu_{itc} \quad \textbf{(eq.1)}$$

Where:

- NLG_{itc} is the dependent variable *Net Loan Growth* observed for the bank "*i*" at the time "*t*" in the country *"c"*
- β_0 is the intercept term,
- RWA_{it}, $IRBA_{it}$, and $Capitalization_{it}$ are the main time-variant covariates.
- $CAMELS_{it}$ is the set of control variables observed for the bank "*i*" at the time "*t*".
- $Macroeconomic_t$ is the set of macroeconomic control variables observed at the time "*t*" affecting all banks "*i*" in the country *"c"*
- α_i is unobserved time-invariant bank' effect. For example, the commercial historical and ability of banks or other institutional factors affecting each bank in a given country.
- μ_{it} is the error term.

To test if the FE provide better estimators that RE, we run the Hausman test (Ba et al., 2021). The null hypothesis of the Hausman test is that the difference in coefficients between both models is not systematic. In other words, under the null hypothesis, the RE is the

preferred model. If we reject the null hypothesis, the FE is the model that better fits our data[6]. Before running the Hausman test, we estimated the following RE model:

$$NLG_{itc}=\varphi_0 + \varphi_1 RWA_{it} + \varphi_2 IRBA_{it} + \varphi_3 Capitalization_{it} + \varphi_4 (IRBA_{it} \times Capitalization_{it}) + \sum_{k=1}^{7} \phi_k CAMELS_{k,it} + \sum_{n=1}^{3} \delta_n Macroeconomic_{tc} + U_i + W_{ij} + \mu_{it} \quad \textbf{(eq.2)}$$

Where:

- φ_0 is intercept term (i.e., the average NLG for the entire sample of banks).
- U_i is the bank-specific random effect (i.e., the difference between the NLG at bank *"i"* and the average NLG of all sample.
- W_{ij} is the bank-specific random effect (i.e., it's deviation of the i^{th} bank from the average for the year *"t"* and country *"c").*

The estimations obtained from the FE and RE models and the Hausman test are reported in Table A1 in appendix. The Hausman test does not reject the null hypothesis, thus suggesting that the RE model provides consistent estimators.

Additionally, the variation on our dependent variable can be partially explained by its variation on anterior period (Ba et al., 2021). So, we conducted an additional test to check if we need to run the RE model controlling for bank-year-country fixed effects (*F-test* – null hypothesis: the coefficients of the set binary variable for each bank *"i"*, year "t", and country *"c"* are equal). The results of the *F-test* are reported in Table A2 in appendix. We reject the null hypothesis for bank and year effects but do not reject for the country-effect. Thus, when running the equation 2 (RE model) we need to control bank and time-fixed effects.

[6] for details see Hausman (1976)

5. Findings

5.1. Baseline results

Table 6 reports the findings obtained from equation 2 (RE model) controlling for bank and time-fixed effects. Column I report the results for the main covariates. Column II adds the control variables. Column III introduces the interaction between *IRBA* and *Capitalization* to test our Hypothesis H3.

The estimations report a statistically significant negative coefficient for the variable *RWA* (Columns I-III: p-value<0.01). This result is in line with Hypothesis H1. We found evidence that an increase in *RWA* have a negative effect on the bank lending. Thus, this result imply that increased capital requirements have a negative effect on lending being this result in line with European literature (e.g., Bridges et al., 2014; Fraisse et al., 2019; Imbierowics et al., 2021; Gropp et al.,2019; Noss et al., 2016).

The negative coefficient of the *IRBA* ratio turns to be non-statistically significant in Column II when we introduce bank-macro control variables (p-value>0.1). Hence, we reject our Hypothesis H2. We did not find evidence supporting that banking lending activity is (positively) impacted by an increase in *IRBA* ratio. Our sample's features could be one reason for this outcome. Because our sample is composed only for G-SIB and O-SIBs, our sample banks are able to avoid engaging in regulatory arbitrage, which is more common among smaller banks (Behn et al., 2022). Additionally, Blum et al. (2008) noted that regulatory arbitrage is more potent when regulatory supervision is weaker. Again, since most of the banks in our sample are G-SIBs and O-SIBs, regulators should scrutinize them more closely, which may deter them from engaging in regulatory arbitrage. Banks therefore seem to be employing the approaches solely for the purpose of enhancing risk assessment as they are unable to benefit from lower requirements (Beltratti et al., 2016; Cucinelli et al., 2018).

Table 6. Baseline model (Method Random Effect with time bank-year fixed effects)

	Column I Main covariates	**Column II** [+] Controls	**Column III** [+] Interactions
Independent Variables			
RWA	-47.259***	-64.558***	-65.777***
	(11.626)	(15.250)	(15.373)
IRBA	-11.951*	-6.486	-12.282
	(6.518)	(6.625)	(10.813)
Capitalization	79.710*	64.796	13.242
	(45.443)	(58.015)	(95.618)
Interaction			
IRBA x Capitalization			71.988
			(106.059)
Control Variables			
Bank characteristics			
Total Assets		-0.000	-0.000
		(0.000)	(0.000)
Capital Adequacy		-28.164	-28.381
		(19.881)	(19.907)
Return on Average Assets		3.952***	4.127***
		(1.138)	(1.168)
Last		-0.039*	-0.039*
		(0.021)	(0.021)
Overhead		487.919*	516.727*
		(291.390)	(294.803)
Cash		0.023	0.022
		(0.016)	(0.016)
NPL		-7.969	-3.237
		(14.915)	(16.479)
Macroeconomic characteristics			
GDP growth		-6.382	-6.732
		(18.809)	(18.838)
Credit to private		-0.061	-0.060
		(0.082)	(0.082)
Euribor		-396.879	-418.238
		(359.607)	(361.402)
Control Fixed effects (Bank, Year)	Included	Included	Included
Constant	27.745***	37.934***	42.047***
	(7.089)	(11.552)	(13.057)
Observations	307	307	307
Number of BNK_ID	60	60	60
R-squared *(within)*	0.1421	0.2206	0.2221
Model performance			
Wald chi-squared	0	318.01	317.72

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The *Capitalization* ratio does not exert a statistically significant effect on the bank lending (Column II-III, p-value>0.10). This result implies that capital structure of a company has no

impact for bank lending. The coefficient of the interaction *IRBA x Capitalization* (Column III) is not statistically significant thus rejecting the Hypothesis H3. Hence, we did not find evidence that an increase in IRBA ratio increases banking lending (H1) even for lower capitalized banks (H3). As mentioned in our literature review, one of the reasons that makes banks more capitalized react less to requirements is the availability of funds to absorb the extra requirements (Berrospide et al., 2010). Consequently, one possible explanation for our result, is that for the banks of our sample their sheer size and importance makes the access to extra funding easier allowing better fund substitution than smaller banks. Consequently, this could explain why the reaction of lending to a change on capital requirements imposed by the adoption of IRBA would not be influenced by the bank's capitalization level.

When examining the results for the control variables, the estimations report a statistically significant positive coefficient for the variable *Return on Average assets* statistically significant (Columns II-III: p-value<0.01). This result implies that banks that earn more, lend more. Despite the negative coefficient of the variable *Last* being statistically significant (Columns II-III: p-value<0.1) the coefficient is very small implying that the impact of this market risk variable, despite significant, is limited. The positive coefficient of the *overhead* is statistically significant (Columns II-III: p-value<0.1). This result implies that banks with more overhead costs lend more.

The variables *Total Assets, Capital Adequacy, Cash, NPL, GDP Growth, Credit to private* and *Euribor* do not exert a statistically significant effect on the bank lending (Column II-III, p-value>0.10).

5.2. Additional analysis

Table 7 reports the estimations obtained when we regress the growth of lending activity on new metrics for our main covariates. Instead of measuring RWA, IRBA and Capitalization as a ratio we now introduce those variables as binary variables based on the median value of each one. The new variable *RWA_b*, (*IRBA_b*, *Capitalization_B)* take the value 1 if the bank "*i*" has a *RWA (IRBA*, *Capitalization)* above the median, and 0 otherwise. Therefore, the coefficient of these variables measures the impact of high RWA, IRBA, and Capitalization ratios on banking lending.

Table 7. New measures of the main covariate variables (Method: Random effects with bank-year fixed effects)

	Column I Main covariates	**Column II** [+] Controls	**Column III** [+] Interactions
Independent Variables			
RWA_b (*binary: above the median*)	-4.113***	-4.268***	-4.270***
	(1.546)	(1.584)	(1.590)
IRBA_b *(binary: above the median)*	-3.848	-3.900*	-3.872
	(2.348)	(2.335)	(2.809)
Capitalization_b *(binary: above the median)*	-0.085	-0.396	-0.372
	(1.799)	(1.796)	(2.236)
Interaction			
IRBA_b x Capitalization_b			-0.053
			(2.951)
Control Variables			
Bank characteristics			
Total Assets		0.000	0.000
		(0.000)	(0.000)
Capital Adequacy		-6.703	-6.715
		(17.043)	(17.094)
Return on Average Assets		3.259***	3.259***
		(1.055)	(1.058)
Last		-0.028	-0.028
		(0.021)	(0.021)
Overhead		-9.479	-9.390
		(257.401)	(258.009)
Cash		0.031*	0.031*
		(0.017)	(0.017)
NPL		-23.295	-23.340
		(14.891)	(15.134)
Macroeconomic characteristics			
GDP growth		-4.572	-4.598
		(19.314)	(19.409)
Credit to private		-0.110	-0.110
		(0.078)	(0.078)
Euribor		-279.561	-279.713
		(371.233)	(372.140)
Control Time fixed effects (Bank, Year)	Included	Included	Included
Constant	12.261***	25.778**	25.749**
	(3.656)	(10.023)	(10.180)
Observations	307	307	307
Number of BNK_ID	60	60	60
R-squared *(within)*	0.1097	0.1904	0.1904
Model performance			
Wald chi-squared	0	297.56	296.27

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Our estimations report a negative coefficient for the variable *RWA_b* (Columns I-III: p-value<0.01). This result is aligned with that reported in Table 6 thus confirming that an increase in *RWA* have a negative effect on the bank lending (H1). Interestingly, and contrary to the results reported in Table 6, the negative coefficient of the binary variable *IRBA* is statistically significant in Column II (p-value<0.10) when the interaction term is not included in our model. This result seems to suggest that in fact an increase of IRBA ratios might reduce the lending activity. However, this is effect seems to be noticeable only for higher IRBA ratios (captured by this binary variable) because in Table 6 we found the effect is not statistically significant (when measured as a continuous variable).

In line with evidence shown in Table 6, the *Capitalization* ratio does not exert a statistically significant effect on the bank lending. The coefficient of the interaction *IRBA x Capitalization* (Column III) is not statistically significant which is consistent with findings reported in Table 6. When we introduce this interaction term, the coefficient of IRBA_b loses statistically significance which might be due to low number of observations by each group (i.e., high IRBA and Low Capitalization [$\varphi IRBA\_d_{it}$]; low IRBA and High Capitalization [$\varphi Capitalization\_d_{it}$]; and High IRBA and High Capitalization [$\varphi_1 RWA\_d_{it}$ x *Capitalization*$\_d_{it}$].

As we mentioned, differences from estimations obtained from IRBA measured as a continuous variable (Table 6) and as a binary variable (Table 7) seem to suggest that the effect of an increase of IRBA depends on the level of that ratio. Inspired by this interesting result, we now extend our analysis to examine if IRBA does play a non-linear effect on banking lending. To do so, for the full model without interactions, we introduce the quadratic term of the IRBA ratio to the equation. The results are reported in Table 8.

Table 8. Non-linearity of IRBA effect (Method: Random Effects with bank-year fixed effects)

	Column I Main covariates	**Column II** [+] Controls
Independent Variables		
RWA	-47.576***	-67.667***
	(11.494)	(15.231)
IRBA	-52.341***	-39.768**
	(17.042)	(17.917)
IRBA squared	35.932**	28.929**
	(14.035)	(14.485)
Capitalization	96.755**	85.270
	(45.415)	(58.547)
Control Variables		
Bank characteristics		
Total Assets		-0.000
		(0.000)
Capital Adequacy		-30.881
		(19.800)
Return on Average Assets		3.568***
		(1.147)
Last		-0.038*
		(0.021)
Overhead		465.699
		(289.728)
Cash		0.021
		(0.016)
NPL		-0.584
		(15.273)
Macroeconomic characteristics		
GDP growth		-7.738
		(18.700)
Credit to private		-0.064
		(0.081)
Euribor		-510.175
		(361.768)
Control Time fixed effects (Bank, Year)	Included	Included
Constant	35.053***	46.107***
	(7.567)	(12.185)
Observations	307	307
Number of BNK_ID	60	60
R-squared *(within)*	0.1651	0.2339
Model performance		
Wald chi-squared	0	326.13

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results provide evidence of a U-shape relationship between the ratio of IRBA and the lending activity, as Table 8 reports a negative coefficient for the variable *IRBA* (Column I, p-value<0.01; Column II, p-value<0.05) and a positive coefficient for the

IRBA_squared (Columns I-II, p-value<0.05). This result implies that when a bank has a lower percentage of their RWAs computed using IRBA an increase of the ratio of IRBA impacts negatively the lending activity. However, the more a bank implements IRBA the lower is the marginal negative impact, until it arrives to point where extra adoption of IRBA within its portfolio causes an increase in lending. One possible explanation is the high fixed cost associate with the implementation of IRBA (Drumond, 2009; Hakenes et al., 2011). Consequently, recently IRBA adopters even if they would get capital requirements benefits, would need to incur in bigger expenses limiting the amount of credit they could give. Additionally, for banks with already IRBA methodologies in place, the fixed costs were already in place and possible not increase as much. So, the more IRBA the bank adopts the more they are "saving" in requirements for the same cost. This evidence opens a new avenue for further research.

6. Conclusion

In response to the recent multiple macroeconomic shocks, a new framework was implemented to improve the stability of the financial sector. Initial Basel accords demanded banks to hold a given percentage of their exposures on high liquid capital. Later, revisions to the framework gave an extra option – *IRBA* - to the already existing CR calculation method. This approach would enable banks to calculate CR using internal estimations, resulting in different requirements for the same set of exposures. Previous research suggests two theories regarding the use of this approach. Firstly, this new approach would align better risk to reality since it would use internal bank estimates. Secondly, some banks would use this methodology to underreport RWAs getting a benefit on CR. This change on capital requirements, according to bank lending channel theory would be felt through bank's lending. Motivated by both the mixed literature on lending channel on Europe and due to the future implementations of Basel IV we tested the capital requirements impact on lending. Additionally, we analysed if the usage of a certain capital requirements approach would lead to a lending competitive advantage.

For our analysis we rely on a panel data with information collected from Bank's regulatory disclosure reports and Bankscope on 60 banks operating in the EU (all G-SIBs or O-SIBs) from 2016 to 2021. We examined the effect of RWAs, IRBA and Capitalization on bank lending relying on a panel data random effects model. Our results shown evidence of a negative impact of RWAs on bank lending. This result suggests that the transmission of monetary policy through the bank lending channel is felt on the European Union. Consequently, we can expect that changes on capital requirements will impact bank's lending. Our initial results for the linear impact of IRBA on lending are not statistically significant. However, we found that IRBA might excerpt a U-shaped effect on bank lending. These results bring several possible implications. First off, the fact that IRBA adopters see their loan amounts decline confirms research that claims there are large initial fixed costs associated with IRBA adoption. (Drumond, 2009; Hakenes et al., 2011). Secondly, it allows policy makers to understand that IRBA methodology is being used as intended, with limited arbitrage. Thirdly, it enables policy makers to comprehend how punitive IRBA adoption is for banks with lower ability to implement costly IRBA. Our results on Capitalization' impact on lending is not statistically significant. This results imply that capital structure does not impact the lending. Our findings on the influence of Capitalization on the effect of IRBA on lending are not statistically significant, indicating that the impact of IRBA on lending is

unaffected by the capital structure of the bank.

This study makes significant contributions to both the literature on capital requirements and bank lending channels and policymakers. First, by investigating the RWA impact on bank lending we add to the bank lending channel debate on the presence of this effect on the European union. Following, by investigating the IRBA impact on bank lending we add an extra dimension to lending channel theory where the methodology influences the lending channel. Additionally, our result contributes to literatures of the regulatory arbitrage hypothesis and internal information hypothesis. Furthermore, it adds to literature on the effects of capitalization on the transmission of the banking lending channel Finally, it contributes for policy makers to understand how banks react to the implementation of IRBA, potentially directing police makers to make adequate changes to mitigate the adoption disadvantages.

We consider our sample the main limitation of the present study. Our sample is only composed of 60 banks from 19 countries and there are multiple countries with a very limited number of observations. Thus, our sample may not be picking up effect from all European Union but of small number of countries. Additionally, our sample is composed by only big and well-established banks which may be skewing some of our results. For example, our sample banks are more prone to regulatory check since they are G-SIBs or O-SIBs, consequently the likelihood of regulatory arbitrage is lower (Blum et al., 2008). As a result, future research could follow numerous different venues. Using a bigger and more diverse sample, both in terms of number of observations, country variety and bank size. Alternately, future studies with objectives comparable to those of this one might be conducted using post Basel IV data (that is under implementation right now). Finally, testing IRBA impact on the lending channel of the U.S. market seems interesting to be able to compare how this effect changes between market-based and bank-based economies.

Appendices

Appendix I

Table A 1. Preliminary Analysis: Fixed Effects *versus* Random Effects

	Column I Fixed Effects	**Column II** Random Effects
Independent Variables		
RWA	-63.455***	-25.120***
	(15.069)	(8.573)
IRBA	-9.188	0.537
	(10.523)	(5.186)
Capitalization	41.799	14.950
	(95.307)	(52.796)
Interaction		
IRBA x Capitalization	39.299	-36.140
	(105.499)	(58.019)
Control Variables		
Bank characteristics		
Total Assets	-0.000	-0.000
	(0.000)	(0.000)
Capital Adequacy	-27.939	-3.324
	(19.744)	(6.543)
Return on Average Assets	4.279***	3.547***
	(1.167)	(0.825)
Last	-0.030	-0.008
	(0.021)	(0.015)
Overhead	495.512*	295.515*
	(296.766)	(160.898)
Cash	0.014	0.012
	(0.016)	(0.015)
NPL	-8.430	-15.096
	(16.350)	(10.890)
Macroeconomic characteristics		
GDP growth	5.149	9.599
	(10.879)	(9.691)
Credit to private	-0.085	-0.048
	(0.076)	(0.033)
Euribor	-164.301	-123.457
	(305.010)	(261.568)
Constant	33.008***	11.476*
	(11.894)	(6.413)
Observations	307	307
Number of Banks	60	60
R-squared (within)	0.1869	0.1654
Model performance		
F-test	3.83***	
Wald chi-squared		62.00***

Hausman test (H0: *Difference in coefficients not systematic* (i.e., RE is the appropriate model))

Chi-squared (p-value)	14.51
P-value	0.151

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix II

Table A 2. Preliminary Analysis: Control for fixed effects (Method: Random effects)

	Column I *Bank*	**Column II** *Year*	**Column III** *Country*
Independent Variables			
RWA	-63.455***	-25.461***	-40.874***
	(15.069)	(8.609)	(9.733)
IRBA	-9.188	0.672	3.215
	(10.523)	(5.183)	(6.403)
Capitalization	41.799	20.919	53.132
	(95.307)	(53.205)	(70.162)
Interaction			
IRBA x Capitalization	39.299	-34.679	-9.672
	(105.499)	(57.997)	(72.451)
Control Variables			
Bank characteristics			
Total Assets	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Capital Adequacy	-27.939	-3.266	-23.015
	(19.744)	(6.532)	(16.049)
Return on Average Assets	4.279***	3.404***	3.199***
	(1.167)	(0.831)	(0.915)
Last	-0.030	-0.012	-0.003
	(0.021)	(0.015)	(0.016)
Overhead	495.512*	280.600*	181.261
	(296.766)	(160.964)	(184.016)
Cash	0.014	0.019	0.012
	(0.016)	(0.015)	(0.015)
NPL	-8.430	-15.348	-8.681
	(16.350)	(11.194)	(14.567)
Macroeconomic characteristics			
GDP growth	5.149	-13.150	8.774
	(10.879)	(17.304)	(10.663)
Credit to private	-0.085	-0.051	-0.107
	(0.076)	(0.033)	(0.073)
Euribor	-164.301	-439.293	-95.881
	(305.010)	(325.611)	(284.266)
Control Fixed effects			
Bank	*Included*	*Not included*	*Not included*
Year	*Not included*	*Included*	*Not included*
Country	*Not included*	*Not included*	*Included*
Constant	39.277***	13.024**	28.344***
	(13.185)	(6.422)	(10.649)
Observations	307	307	307
Number of BNK_ID	60	60	60
R-squared (Within)	0.1869	0.1945	0.1665
Model performance			
Wald-test	299.19***	74.53***	85.97***
Test for year-bank-country-fixed effects (H0: *the coefficients of the set binary variable for each bank* "i"*, year* "t"*, and country* "c" *are equal*)			
Chi-squared	180.33	11.19	21.98
p-value	0.000	0.025	0.233

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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