Internal Rating Based Model, Bank Regulatory Arbitrage and Eurozone Crisis

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Abstract

I investigate how the complicated model-based capital regulation can be misused by European banks for capital saving purposes. I find that relative to banks from core countries, banks from peripheral countries (1) can greatly reduce the risk-weight associated with their assets by applying more internal rating-based (IRB) approach, and (2) the default frequency of their assets is not reflected in the risk-weight. On the other hand, peripheral banks (3) use less IRB approach, especially regarding exposure of the public sector. These results indicate that banks from peripheral countries are more likely to abuse the model-based capital regulation, by both strategically manipulating the risk-weights under the IRB models and avoiding IRB approach on certain exposures. Those findings support the concerns raised in the recent regulatory proposal (EBA 2016). In particular, not only the use of IRB should be carefully granted and closely supervised, but also the (permanent) partial use of IRB should be limited, so that both strategic IRB modelling and the so-called cherry-picking can be properly confined.

JEL Classification: G01, G21, G28

Keywords: Internal ratings-based approach, Capital Regulation, Regulatory Arbitrage, Eurozone Crisis

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1. Introduction

In order to increase the stability of the financial system, policy makers have been improving the regulatory framework, with particular attention to the design of bank's capital charge. In this regard, the most important innovation is the model-based capital regulation, which is introduced around the new Millennium. Regulations under Basel II allow banks to choose between two different approaches to assess the risk associated with their assets as well as capital adequacy, namely the internal rating-based approach (IRB) and the standard approach (SA). Specifically, the IRB approach enables banks to design and calibrate their own risk models, subject to approval of the supervisors. Thus, it ties the capital charge to the actual risk of specific asset. Regulators believe that capital requirement based on such an approach can be more sensitive to the drivers of risks, and an appropriately structured framework can motivate banks to improve their internal risk management (BCBS 2001). However, critics point out that complex and opaque rules can create high compliance costs and barriers to entry (BCBS 2004). More importantly, by applying internal based models, banks can have considerable autonomy in terms of risk assessment, which can provide extensive incentive for regulatory arbitrage. Mariathasan and Merrouche (2014) find that risk-weight density of the bank becomes lower once regulatory approval of using IRB approach is granted, and suggest that part of the decline in reported riskiness under the IRB approach is due to strategic risk modelling. Ferri and Pesic (2016) provide evidence of regulatory arbitrage and show that such effect is stronger at banks that adopt the Advanced-IRB than those only have Foundation-. By exploiting the Germany banking sector using loan-level data, Behn et al (2016) show that IRB approach underpredicts actual default rates by 0.5% - 1%. They also show that loans, originated under IRB, have higher default rates and higher interest rates than those originated under SA, which suggests that banks were aware of the higher risk associated with these loans and priced them accordingly, but reduced capital charge by under estimate the corresponding risks via IRB models.

This paper contribute to the literature mainly from two aspects. First, I explore the regulatory arbitrage via strategic modelling IRB models in the context of the Eurozone crisis. A few papers with similar intention have found indication of regulatory arbitrage (Vallascas and Hagendorff 2013; Beltratti and Paladino 2016; Ferri and Pesic 2016). However, due to data availability, they were not able to tell the effect of Eurozone crisis on regulatory arbitrage clearly. In this paper, the data from European Banking Authority (EBA) allows me to conduct analysis at geographical portfolio level rather than just bank level. I find that the regulatory arbitrage by strategically modelling is largely related to banks from the Eurozone peripheral countries. Also, I show that banks are more likely to engage in regulatory arbitrage in the absence of macro shock or capital shock, that is, banks may try to drain capital in tranquil times to make more profit, and have to build up capital during stressed situations. Such results can be very important, as it indicates that IRB approach may facilitate risk taking and make the banking sector more procyclical.

Second, apart from the regulatory arbitrage by using IRB approach, I also show that peripheral banks may game the risk weights by avoid using IRB approach on certain exposures, which is the so-called cherry-picking issue. The Basel Committee requires that, once a bank uses the IRB approach for one part of its asset, it must take steps to implement the IRB approach across all significant portfolios and business lines (BCBS 2001). In this paper, I show that some banks from peripheral countries barely apply IRB approach to their exposure to the public sector, which can be quite material in terms of size and riskiness; meanwhile, IRB approach is widely used among their private sector exposures. Further, I show that cherry-picking can be facilitated by the largely criticised zero-risk-weight for investment in sovereign debt[1], which

[1] The European CRDs have introduced a generalised zero risk weight which is not in line with the spirit of Basel II. Article 89(1)(d) of the CRD (amended by Directive 2009/111/EC or "CRD II"), and Annex VI Part 1 paragraph 4 assign a risk weight of 0% for "exposures to Member States' central government […] denominated and funded in the domestic currency of that central government"

supports the criticism regarding the "IRB permanent partial use" mentioned by Hannoun (2011)[2].

In addition, this paper relates more broadly to the literature on the sovereign-bank "doom loop", that is, the destabilising link generated by potential default risk spillovers between banks and sovereigns through banks' government bond holdings (Cooper and Nikolov (2013), Farhi and Tirole (2014), Acharya et al. 2014 and Brunnermeier et al. (2016)). I observe near-zero risk-weight assigned by some peripheral banks to their public sector exposures via standardised approach, especially for Greek banks, which can provide great incentive for banks to "carry-trade" (Acharya and Steffen, 2015). Also, it may have facilitated the unexpected trend observed by Liu and Varotto (2017) that small local banks in peripheral countries have increased sovereign bond holdings dramatically in recent years.

The paper proceeds as follows. In section 2, I introduce the data set and present some summary statistics. In section 3, I explain the empirical model. In sections 4, I discuss the results regarding the regulatory arbitrage via strategic IRB modelling. In section 5, I further discuss the cherry-picking issue due to the permanent partial use of IRB. Section 6 concludes the paper.

2. Data and Summary Statistics

This section describes the data set and illustrates some difference between banks from different country groups. The sample covers 50 banks from 10 major Eurozone countries which can be generally classified into two groups – "core countries" (Austria, Belgium, Germany, France and Netherlands) and "peripheral countries" (Greece, Ireland, Italy, Portugal and Spain).

[2] Hannoun (2011) claims that "According to the European directive, a bank can apply the IRB approach to corporate, mortgage or retail exposures, while applying a one-size-fits all zero risk weight to the sovereign debt of EU member states. This is equivalent to a mutual and unqualified exemption of certain sovereign risks from capital charges, an exemption inconsistent with Basel II's risk-sensitive framework."

The analysis is carried out for the period covering the following time points, Dec 2012, June 2013, Dec 2013, Dec 2014, June 2015, Dec 2015 and June 2016.

The core of my data is from European Banking Authority (EBA), which discloses detailed information including credit risk related items of banks that participate in the stress tests and risk assessments conducted over the period mentioned above[3]. The number of banks varies among different tests, but according to the EBA, each test covers at least 60% of total EU banking assets. In order to have a consistent data sample, a bank is included if it is from any of the 10 countries mentioned above and participated at least twice in any of the EBA tests. In addition, since I intend to capture strategic modelling through IRB approach, I exclude banks that do not use IRB approach during the period[4]. Table 1 Panel A gives a summary description of the items from the EBA. Basically, it can be classified into two categories – exposure at default (EAD) and risk weighted assets (RWA), and I produce one of the main variables - risk-weight (RW), which simply equals to RWA/EAD. Notably, RWA/EAD can better approximate the true riskiness compared to RWA/TA, as both the reported RWA and EAD considers off-balance sheet items, e.g. credit lines, which can be a considerable part of banking business, while total asset only captures on-balance sheet items. Since EAD and RWA can be divided further based on the default status of the exposure – defaulted and non-defaulted, I can derive the second main variable default frequency of bank's exposure (DF), which equals to default EAD / (default EAD + non-default EAD). Also, EAD can be classified into two groups based on the regulatory approach it is following – standardised approach (SA) and internal rating-based (IRB) approach. Therefore, I get the third main variable – coverage of IRB approach (IRB %), which is equal to EAD_IRB / (EAD_IRB + EAD_SA). The detailed structure of the data allows the analysis to be conducted at geographical-portfolio-level of each bank rather

[3] Transparency Exercise 2013 (December 2012 and June 2013), Stress Test 2014 (December 2013), Transparency Exercise 2015 (December 2014 and June 2015) and Transparency Exercise 2016 (December 2015 and June 2016)
[4] Such exclusion is also necessary due to the empirical method of this paper.

than just bank-level, and Table A1 summarize the geographical breakdown of the observations. In addition to those three main variables described above, there are another three geographical-portfolio-level variables, namely ln(EAD), PRIVATE and GOV, which indicates the log of a bank's EAD to a particular country, the share of exposure to the private sector, and the share of exposure to the governments. Bank level data such as total asset and equity ratio is from Bloomberg, see Table 1 Panel B for a summary description of all variables used in this paper.

Table 2 shows the summary statistics. Panel A compares the difference between banks from core countries and banks from peripheral countries. We can see that the RW and DF of peripheral banks are significantly higher than those of core banks, while IRB approach is more widely used by core banks. To some extent, such results are unexpected as intuitively we may expect a lower RW given a higher IRB%. Thus, I intend to explore the relation between RW and IRB%, and compare such relation between core banks and peripheral banks.

3. Empirical Method

3.1 Roll-Out effect vs. Regulatory Arbitrage

Many papers in the literature have provide evidence that banks carry out regulatory arbitrage via IRB models (Le Lesle and Avramova 2012; BCBS 2013; Vallascas and Hagendoff 2013; Mariathasan and Merrouche 2014). Also, extensive use of IRB approach may considerably reduce risk weights (EBA 2013a; Bruno et al 2014; Ferri and Pesic 2016; Montes et al 2016). However, as emphasized by Ferri and Pesic (2016), the reduced risk weight due to extensive use of IRB approach may not necessary indicate the existence of regulatory arbitrage, since it could be a result of the Roll-Out effect (shifting exposures-at-default (EAD) from SA to IRB), which is a fair use of regulatory options. In other words, in the absence of incentive for arbitrage, IRB approach can still lead to a lower risk-weight because it is supposed to be more efficient in terms of capturing risk factors and more responsive to risk factor changes. In contrast,

reduced risk weight due to unfair use of IRB, e.g. by intentionally under estimate the probability of default (Behn et al 2016), indeed indicates regulatory arbitrage.

3.2 Model

In order to identify bank regulatory arbitrage via strategic IRB modelling, I propose the empirical method as follows:

$$RW_{l,b,c,t} = \alpha + \beta_1 \cdot IRB\%_{l,b,c,t} + \beta_2 \cdot DF_{l,b,c,t} + \delta \cdot P_{l,b,c,t} + \gamma \cdot X_{b,t} + \theta_b + \rho_{c,t} + \varphi_{l,t} + \varepsilon_{l,b,c,t} \quad (1)$$

Where (l) denotes the home country of the bank, (b) indicates the specific bank, (c) is for the country of exposure and (t) identifies the time. The dependent variable is the risk weight, which equals to RWA/EAD. IRB% fully controls for Roll-Out effect and may partially reflect regulatory arbitrage, that is, it is difficult to conclude whether the reduced risk weight is purely driven by the Roll-Out effect or regulatory arbitrage through manipulation, or a combination of both mechanisms. Anyways, I expect to see a negative sign for β_1. In order to better distinguish regulatory arbitrage from Roll-Out effect, DF, default frequency of exposures, is introduced to approximate the true risk of the exposure, and the estimation of β_1 and β_2 may indicate the existence of arbitrage. Specifically, since the project risk should be compatible with the true risk, thus, β_2 should be positive and significant in the absence of arbitrage. In contrary, if β_1 is very negative and statistically significant while β_2 is not positively significant, i.e. risk-weight can be greatly reduced by applying more IRB approach but the project risk does not reflect the realised true risk, which can indicate regulatory arbitrage. I also include 3 country-portfolio level control variables ($P_{l,b,c,t-1}$), namely, EAD: log of a bank's total EAD in a country, PRIVATE: proportion of EAD to retail sector and corporate sector, and GOV: proportion of EAD to the government sector. Additionally, there are 2 bank level control variables ($X_{b,t-1}$): log of total assets (SIZE) and total equity/total asset (CAP). Notably, there

may be reverse causality regarding the two major explanatory variables - IRB% and DF; in particular, banks may use more IRB approach simply because they know that it will lead to lower risk-weight, and the contemporary risk-weights indicate the current risk level, which will affect the contemporary default frequency. To deal with the endogeneity issue, I use $IRB\%_{l, b, c\_other, t}$ (named Z_1) as instrument for $IRB\%_{l, b, c, t}$, since, for a particular bank, the use of IRB approach in its exposure to one country can be related to that of the other countries, while the risk-weight of the same exposure may not have any direct relation with the use of IRB approach in the other countries. Similarly, I use $DF_{l, b, c\_other, t}$ (named Z_2) as the instrument for $DF_{l, b, c, t}$. Fixed effect controls are included at levels of bank, home-country*time and exposure-country*time. (1) is estimated with observations of core countries' banks and peripheral countries' banks separately. All variables are winsorized at 1% 99%, and standard errors are clustered at bank*time level.[5]

4. Results

4.1 Baseline Model

In this section, I discuss the results of analysis on banks regulatory arbitrage via strategic IRB risk-weights modelling. Table 3 shows the baseline results. Compared to core banks, peripheral banks can greatly reduce their risk-weights by applying more IRB approach. In specific, the risk-weights of peripheral banks (core banks) can decrease by 0.56% (0.10%) if the coverage of IRB approach is increased by 1% upon the banks exposures, and the corresponding coefficient – IVIRB%, is more statistically significant for peripheral banks. However, as mentioned in Section 3.1, such a high risk-weights reduction observed for peripheral banks may not be necessarily associated with regulatory arbitrage. So, we need to investigate the impact of the other core variable – default frequency, on risk-weights. For

[5] Similar result can be obtained, by winsorizing at 2% and 98% and/or clustering at bank level.

peripheral banks, the project risk does not reflect the true realised risk as the coefficient of IVDF is not statistically significant; meanwhile, a 1% increase in default frequency of exposures hold by core banks can effectively lead to a 1.75% increase in the risk weight, i.e., project risk is highly responsive to realised risk. Combined with the different estimations regarding IRB%, it may indicate that peripheral banks are more likely to be involved with regulatory arbitrage via strategic modelling than core banks.

Notably, there is a difference between the estimation of the instrument variable for DF (Z_2) in column [2] and [5]. Specifically, the default frequency of a core bank's exposure in one country is negatively associated with the default frequency of its exposures in other countries, which may reflect a more effective diversification. In contrast, there is no clear relationship among a peripheral bank's exposures in different countries. EAD has a negatively significant coefficient in both [3] and [6], which is not surprising since once a bank is approved to use IRB, it is required to apply IRB approach to its main business segments and encouraged to apply IRB to its entire business in order to avoid the so-called cherry picking issue. In other words, under the internal capital-saving incentive and external compliance pressure, bank will tend to design and apply IRB models that favours their major business segments. The sign of PRIVATE (GOV) is positive (negative) for both core banks and peripheral banks in [3] and [6], which is not surprising. However, the absolute scale of the coefficients are larger for peripheral banks, 0.49 vs 0.16 for PRIVATE and -0.40 vs -0.15 for GOV. Such results are interesting because it indicates that peripheral banks can greatly reduce risk weights by holding by government exposures, while the sovereign exposure they hold may not be actually safe[6], and I will discuss this further in Section 5.

[6] Peripheral banks tend to have a very strong home bias in sovereign exposure (Liu and Simone 2017), and those sovereign bonds were highly risky during the eurozone crisis period.

4.2 Exposure to GIIPS

Regarding the result in the last section that peripheral banks are more likely to carry out regulatory arbitrage than core banks, it is possible that such behaviour is driven by the exposed country. In other words, peripheral banks are more subject to regulatory arbitrage because they are more exposed to peripheral countries due to home bias, and we may identify regulatory arbitrage in core banks' peripheral exposures. Some summary statistics comparing exposure to peripheral countries (GIIPS) and other countries (NonGIIPS) are presented in Table 4. In Panel A, core banks' NonGIIPS exposure are less risky than their GIIPS exposure in terms of both RW and DF; meanwhile, in Panel B, peripheral banks' NonGIIPS exposure has a higher RW than their GIIPS exposure, but the default ratio of GIIPS exposure is much higher (4 times) than that of the NonGIIPS exposure. Also, peripheral banks' use more IRB approach in their GIIPS exposure than NonGIIPS exposure, around twice as much. Thus, it may indicate that peripheral banks strategically manipulate the risk weights of their GIIPS exposure under IRB approach for capital saving purposes.

Then I formally test this point using the baseline model with a dummy variable GIIPS which equals to 1 if the exposed country is Greece, Ireland, Italy, Portugal or Spain. GIIPS is also interacted with IVIRB and IVDF separately in the second stage of the 2SLS regression. According to the results in Table 5 Column [3], core banks' NonGIIPS exposure has a quite different result compared to their GIIPS exposure. Specifically, using more IRB approach in NonGIIPS exposure will lead to a lower risk weight, while there is no significant relationship between IRB% and risk weight in GIIPS exposure; meanwhile, higher default ratio of NonGIIPS exposure will lead to higher risk weight, but there is no link between default ratio and risk weight in GIIPS exposure. Therefore, it indicate that core banks are very unlikely to be involved with regulatory arbitrage by using IRB approach even regarding their GIIPS exposure (which is more risky), as there is not any benefit of capital saving related to applying

more IRB approach, i.e. no incentive for arbitrage. In contrast, for peripheral banks in column 6, their NonGIIPS exposure and GIIPS exposure have quite similar results – in both kind of exposures, more use of IRB can lead to lower risk weight, but no link between default ratio and risk weight. Such results may indicate that the potential regulatory arbitrage is more associated with peripheral banks, rather than exposures to GIIPS countries of all banks.

4.3 Regulatory Arbitrage under Shocks

It is important to identify the impact of capital shock on regulatory capital arbitrage, because a bank with the limited capital may have more incentive to manipulate the risk weights in order to improve their tier 1 capital ratio to meet the capital requirement as well as demonstrate a better image for investors. Accordingly, I include two dummy variables $POORCAP_{b,t}$ and $UNDERCAP_{b,t}$, which represents poorly capitalised bank (with tier1 ratio lower than 10% but higher than 8% at a particular time) and undercapitalised bank (with tier1 ratio falls below the minimum requirement 8% at a particular time) respectively. Also, the corresponding interaction terms with IVIRB and IVDF are included, so that the marginal effect of capital shock on regulatory arbitrage can be captured. According to the results in Panel A Table 6, for both core banks and peripheral banks, when they have a capital shock – regular or serious, the risk weight is no longer associated with the use of IRB. Thus, it is very unlikely that banks, under a capital shortfall, are involved with regulatory arbitrage by using IRB approach, as there is no benefit of capital saving by using more IRB approach. Such results may reflect that when a bank is in (or near) capital shortfall, it is probably under stringent regulation so that it is difficult to carry out strategic manipulation.

Then, when there is a macro shock to a particular country, banks may be required to hold excess capital regarding their exposure in that particular country. Regulatory arbitrage may arise if banks perceive the cost of raising extra capital being too high, then, they may deleverage

themselves by strategically underestimate the riskiness of the corresponding exposure, i.e. regulatory arbitrage regarding the exposure within the distressed country. By following Brutti and Saure (2016), a country is categorized as "in crisis" ($CRISIS_{c,t}$) if a country is a Euro member and its average daily 10year bond spreads (with respect to Germany) for the previous three months was above 400 basis points. I add CRISIS and the interaction IVIRB*CRISIS and IVDF*CRISIS to the baseline model, and the result is reported in Panel B Table 6 Column [1] for core banks and Column [3] for peripheral banks. Similar to the result for capital shocks, for both core banks and peripheral banks, when there is a macro shock to a particular exposed country, the risk weight of exposures in this country is no longer associated with the use of IRB. Thus, it is very unlikely that banks, even peripheral banks, to carry out regulatory arbitrage regarding their exposure to a country which is in distress. Similarly, banks may perform regulatory arbitrage when their home country is in crisis, and they may carry out such arbitrage regarding their exposure in all countries indiscriminately. Accordingly, a dummy variable, $Stressed_{l,t}$, and the corresponding interactions are introduced. As can been seen from Table 6 Panel B, the results are quite similar to that of "CRISIS".

Overall, it seems that when there is a shock (either macro level or bank specific), banks tend to react cautiously and stop strategic manipulation (if any) regarding this specific shock. However, in the absence of shocks, banks, especially peripheral banks, are very likely to conduct strategic manipulation for capital saving purpose, since the estimation of the standalone IVIRB and IVDF (Table 6) are quite similar to those of the baseline model (Table 3).

5. Capital saving by avoiding IRB approach.

As mentioned in Section 4.1, banks may try to reduce risk weight also by avoiding using IRB approach on certain exposures - "cherry-picking". Such strategy can be facilitated by the

"IRB permanent partial use (PPU)" rules, in which an EU bank can apply the IRB approach to corporate, mortgage or retail exposures, while applying a one-size-fits all zero risk weight to the sovereign debt of EU member states (Hannoun 2011). Also, local competent authorities possess considerable flexibility in terms of the authorization of PPU, which leads to a high variance of practice regarding PPU among different countries (EBA 2013b).

I aggregate the data of all banks in my sample by their country of origin. The proportion of IRB exposures at the aggregate country level regarding different sectors are shown in Figure 1. Graph (A) shows the IRB coverage regarding exposures to all sectors, and it clearly reveals variation in the use of IRB approach across countries. In specific, banks from south Europe – Greece, Italy and Spain, have the lowest level of IRB exposure. In Graph (B), I show the proportion of IRB exposures regarding the private sector (retail plus corporate) and the public sector (central and regional governments). Surprisingly, there are banks from many countries that barely use IRB approach regarding government exposure, which include not only south European banks but also Scandinavian banks. However, such partial use of IRB may only indicates "cherry picking" issue in south European banks, because, first, government exposure constitutes a less significant proportion in Scandinavian banks (Figure 2), which satisfies one of the main requirement of PPU – PPU only in immaterial business segment; second, only Finland is in the Eurozone[7]. In contrast, the proportion of public sector exposure is a significant part of those south European banks, and those exposures may possess considerable level of risk due to high home bias in those banks portfolio and high default risk of those sovereigns.

Due to data availability, it is difficult to perform formal empirical test of cherry-picking. Instead, some simple evidence is provided in Table 8 to further support the existence of such

[7] The European Capital Requirements Directives only assigns zero-risk-weight for "exposures to Member States' central government […] denominated and funded in the domestic currency of that central government", which is not eligible for banks from Denmark, Norway and Sweden. On the other hand, Scandinavian governments have quite high credit in general, thus, the corresponding risk weight should always be very low if either IRB or SA is applied.

issue. Specifically, the proportion of IRB exposure to the public sector (shown in Graph (B) Figure 1), is now split into three groups – domestic government exposure, non-US foreign government exposure and US government exposure, and the results are reported in Panel A Table 8. In particular, banks from Austria and Italy barely applies IRB for their domestic government exposures, in contrast, IRB is widely used to assess riskiness regarding exposure to the US government. Then, in Panel B, we can see very low risk-weight for some peripheral banks' domestic exposure, especially Greece and Ireland, which may considerably deviate from the true risk level[8]. Also, I use univariate regression to figure out the average impact of IRB proportion on the risk weight of the public (private) sector, and the model is as follows:

$$RW_{total_{l,b,c,s,t}} = \alpha + \beta_1 \cdot IRB\%_{l,b,c,s,t} + Fixed\ Effects \quad (4)$$

Where (*l*) denotes the home country of the bank, (*b*) indicates the specific bank, (*c*) is for the country of exposure, (*s*) represents the sector of exposure and (*t*) identifies the time. The dependent variable is the overall risk weight of exposure under both SA and IRB; IRB% indicates the proportion of IRB for a bank's exposure to a certain sector of a country. The results are reported in Panel C Table 8, and it shows that the impact of IRB% on RW is totally opposite between public exposure and private exposure. Specifically, for private exposure, more use of IRB can reduce risk-weights, which is in line with the Roll-Out effect and/or regulatory arbitrage via strategic IRB modelling. In contrast, for public exposures, IRB% has a positive and significant coefficient, that is, less use of IRB regarding government exposure can save capital, which is line with the evidence provided previously and supports the criticisms of cherry-picking issue associated with permanent partial use of IRB approach.

6. Conclusion

[8] The risk-weights for Italian bank's domestic government exposure is around 14%, which is considerably higher than those of the other peripheral banks' domestic government exposures. It is because this risk -weight became much higher in 2014 (from around 5% to 20%), probably due to policy changes of local competent authority.

By exploiting the relationship between the use of IRB approach and risk-weights of banks assets, I provide evidence that banks may reduce their capital requirement via strategical manipulation using IRB approach - regulatory arbitrage, and/or partial use of IRB approach on certain business segments - cherry-picking. The former is a bank's voluntary behaviour while the latter may be a result of sovereign-bank mutual needs. Particularly, governments of financially distressed countries need domestic banks to absorb their new debt issuance, and those banks have the incentive to improve their regulatory capital ratio as well as seeking for yield; thus, the zero-risk weights that Eurozone banks may assign to their holdings of Eurozone government debt may satisfy the needs of both banks and sovereigns. However, it may greatly contribute to the sovereign-bank doom loop, which has caused serious stress in the recent years. The main findings of this paper support the concerns raised in the recent regulatory proposal (EBA, 2016). In particular, not only the use of IRB should be carefully granted and closely supervised, but also the (permanent) partial use of IRB should be limited, so that both strategic IRB modelling and cherry-picking can be properly confined. On the other hand, I show that banks are more likely to engage in regulatory arbitrage in the absence of macro shock or capital shock, that is, banks may try to drain capital in tranquil times to make more profit, and have to build up capital during stressed situations. Such results should raise considerable concerns, as it indicates that IRB approach may facilitate risk taking and make the banking sector more procyclical.

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Table 1. Variables and Definitions.

Panel A. Description of credit risk items from EBA disclosure.

EBA Item	Explanation[9]
RWA_SA_D	Risk weighted asset under standard approach that is in default
RWA_SA_ND	Risk weighted asset under standard approach that is not in default
RWA_IRB_D	Risk weighted asset under IRB approach that is in default
RWA_IRB_ND	Risk weighted asset under IRB approach that is not in default
EAD_SA_D	exposure-at-default under standard approach that is in default
EAD_SA_ND	exposure-at-default under standard approach that is not in default
EAD_IRB_D	exposure-at-default under IRB approach that is in default
EAD_IRB_ND	exposure-at-default under IRB approach that is not in default

Panel B. Definition of Variables

Name	Definition
	Portfolio Level Variables
RW	$(RWA_{IRB,D\&ND} + RWA_{SA,D\&ND}) / (EAD_{IRB,D\&ND} + EAD_{SA,D\&ND})$
IRB%	$EAD_{IRB,D\&ND} / (EAD_{IRB,D\&ND} + EAD_{SA,D\&ND})$
DF	$(EAD_{IRB,D} + EAD_{SA,D}) / (EAD_{IRB,D\&ND} + EAD_{SA,D\&ND})$
EAD	ln (total EAD to a country)
PRIVATE	Share of exposure to the retail and corporation to total exposure in a country
GOV	Share of exposure to the public sector to total exposure in a country
	Bank Level Variables
SIZE	ln (total asset)
CAP	total equity / total asset
	Dummy Variables
POORCAP	Dummy Variable for banks with tier1 ratio <10% but >8%
UNDERCAP	Dummy Variable for banks with tier1 ratio <8%
GIIPS	Dummy Variable for exposure to a "peripheral country"
CRISIS	Dummy Variable for exposure to a country in crisis
StressedBank	Dummy Variable for banks from a country in crisis

[9] Some tests report figures for Default and “Default&Non-Default” instead.

Table 2. Summary Statistics

The sample covers 50 banks from 10 Eurozone countries for the period covering the following time points, Dec 2012, June 2013, Dec 2013, Dec 2014, June 2015, Dec 2015 and June 2016. Core Bank are banks from Austria, Belgium, Germany, France and Netherland. Peripheral Bank are banks from Greece, Italy, Ireland, Portugal and Spain. RW: risk weight of exposure to a country. IRB%: % of IRB methodology upon EAD. DF: default frequency of exposure to a country. EAD: total EAD to a country, in billion Euro. PRIVATE: the proportion of exposure to retail and corporate over total exposure. GOV: the proportion of exposure to central and regional governments over total exposure. SIZE: total asset of bank, in billion Euro. CAP: total equity / total asset. The significance level of T-test on mean and Wilcoxon test on median are indicated by ***, **, and * for 1%, 5% and 10%, respectively. Variables are winsorized at 1th and 99th percentile. Data source: Bloomberg and EBA.

	Mean			Median		
	Core Bank	Peripheral Bank	Diff.	Core Bank	Peripheral Bank	Diff.
RW	33.2%	46.8%	-13.6%***	30.0%	43.1%	-13.1%***
IRB%	73.7%	40.8%	32.9%***	82.0%	42.0%	40.0%***
DF	2.5%	4.4%	-1.8%***	1.2%	2.1%	-0.9%***
EAD	33.9	57.5	-23.6***	8.6	17.9	-9.3***
PRIVATE	50.6%	53.7%	-3.1%**	52.5%	59.0%	-6.5%***
GOV	22.6%	20.4%	2.2%**	17.0%	18.0%	-1.0%
SIZE	535	529	6	260	624	-364*
CAP	5.0%	6.9%	-1.8%***	4.6%	7.0%	-2.4%***

Table 3. Baseline Results – Regulatory Arbitrage Core Banks VS. Peripheral Banks.

The purpose of this table is to provide evidence of regulatory arbitrage via IRB approach while controlling the Roll-Out effect. The table summarizes the results of the equation (1) estimated over the period from end 2012 to mid-2016 on a near biannual basis (with one gap in mid-2014). Core Banks are banks from Austria, Belgium, Germany, France and Netherland. Peripheral Banks are banks from Greece, Italy, Ireland, Portugal and Spain. The dependent variable for the first stage regression is IRB% (DF), which indicates the % of IRB methodology upon exposure to a country (default frequency upon exposure to a country). Z1 (Z2) is the instrument variable for IRB% (DF), which indicates the % of IRB methodology upon exposure to all other countries (default frequency upon exposure to all other countries). The dependent variable for the second stage regression is RW, risk weight of exposure to a country. IVIRB% (IVDF) is the instrumented IRB% (DF) from the first stage regression. EAD: total ln(EAD) to a country. PRIVATE: the proportion of exposure to retail and corporate over total exposure. GOV: the proportion of exposure to central and regional governments over total exposure. SIZE: ln(total asset of bank). CAP: total equity / total asset. All variables are winsorized at 1st and 99th percentile. Standard errors are heteroscedasticity-robust and clustered at the Bank *x* Time level. ***, **, and * indicate significance at the 1, 5 and 10 percent levels, respectively. All country-portfolio level data are from EBA and all bank level variables are from Bloomberg.

	Core Banks			Peripheral Banks		
	First Stage		Second Stage	First Stage		Second Stage
Dep. Variable	IRB%	DF	RW	IRB%	DF	RW
	[1]	[2]	[3]	[4]	[5]	[6]
IVIRB%			-0.0993*			-0.5573**
IVDF			1.7487**			5.1908
z1	-1.1151***	0.0605***		-0.6422***	-0.0212	
z2	-1.0250**	-0.3098***		-3.2823***	-0.2751	
EAD	-0.0105**	-0.0005	-0.0350***	-0.0113	0.0107***	-0.1030*
PRIVATE	0.1423***	0.0453***	0.1606***	0.3562***	0.0390***	0.4873***
GOV	-0.1170*	-0.0191***	-0.1519***	-0.0648	-0.0146	-0.3951**
SIZE	-0.1301	-0.0047	0.1665***	0.9143**	0.0667	0.2713
CAP	-2.0830*	-0.0622	2.2103***	3.5644	0.1606	1.8914
Bank FE	YES	YES	YES	YES	YES	YES
HomeCountry *x* Time FE	YES	YES	YES	YES	YES	YES
ExpCountry *x* Time FE	YES	YES	YES	YES	YES	YES
N	1624	1624	1624	467	467	467
Adj. R-Squared	0.58	0.47	0.61	0.64	0.78	0.63

Table 4. Exposure to GIIPS Countries and NonGIIPS Countries.

Core Bank are banks from Austria, Belgium, Germany, France and Netherland. Peripheral Bank are banks from Greece, Italy, Ireland, Portugal and Spain. GIIPS indicates a bank's exposures to Greece, Italy, Ireland, Portugal and Spain. NonGIIPS indicates a bank's exposure to countries other than GIIPS. RW: risk weight of exposure to a country. IRB%: % of IRB methodology upon EAD. DF: default frequency of exposure to a country. EAD: total EAD to a country, in billion Euro. PRIVATE: the proportion of exposure to retail and corporate over total exposure. GOV: the proportion of exposure to central and regional governments over total exposure. SIZE: total asset of bank, in billion Euro. CAP: total equity / total asset. Panel A compares the NonGIIPS and GIIPS exposure of Core Banks, Panel B compares the same things but held by peripheral banks, and Panel C compares the GIIPS exposure held by Core Banks and Peripheral Banks. The significance level of T-test on mean and Wilcoxon test on median are indicated by ***, **, and * for 1%, 5% and 10%, respectively. Variables are winsorized at 1th and 99th percentile. Data source: Bloomberg and EBA.

Panel A: Core Banks' Exposure - NonGIIPS VS. GIIPS

	Mean			Median		
	NonGIIPS	GIIPS	Diff.	NonGIIPS	GIIPS	Diff.
RW	31.8%	41.8%	-10.0%***	29.0%	38.2%	-9.3%***
IRB	74.4%	69.6%	4.8%**	84.0%	75.0%	9.0%***
DF	2.3%	4.1%	-1.8%***	1.1%	2.5%	-1.4%***
EAD	36.8	16.0	20.8***	8.9	5.9	3.0***
PRIVATE	51.8%	43.6%	8.1%***	53.0%	46.0%	7.0%***
GOV	22.0%	26.7%	-4.8%***	17.0%	18.0%	-1.0%***

Panel B: Peripheral Banks' Exposure - NonGIIPS VS. GIIPS

	Mean			Median		
	NonGIIPS	GIIPS	Diff.	NonGIIPS	GIIPS	Diff.
RW	49.5%	38.7%	10.8%***	49.3%	40.0%	9.3%***
IRB	35.5%	56.6%	-21.1%***	26.0%	61.0%	-35.0%***
DF	2.5%	9.8%	-7.2%***	1.6%	9.4%	-7.8%***
EAD	31.7	134.6	-102.9***	14.1	65.4	-51.3***
PRIVATE	51.8%	59.5%	-7.7%***	55.0%	67.0%	-12.0%***
GOV	19.1%	24.5%	-5.5%***	17.0%	19.0%	-2.0%***

Panel C: Exposure to GIIPS – Core Banks VS. Peripheral Banks

	Mean			Median		
	NonGIIPS	GIIPS	Diff.	NonGIIPS	GIIPS	Diff.
RW	41.8%	38.7%	3.1%*	38.2%	40.0%	-1.8%
IRB	69.6%	56.6%	13.0%***	75.0%	61.0%	14.0%***
DF	4.1%	9.8%	-5.7%***	2.5%	9.4%	-7.0%***
EAD	16.0	134.6	-118.6***	5.9	65.4	-59.5***
PRIVATE	43.6%	59.5%	-15.9%***	46.0%	67.0%	-21.0%***
GOV	26.7%	24.5%	2.2%	18.0%	19.0%	-1.0%

Table 5 Regulatory Arbitrage Regarding GIIPS Exposure, Core Banks VS. Peripheral Banks.

The purpose of this table is to test whether regulatory arbitrage is stronger regarding exposures to peripheral countries. Core Banks are banks from Austria, Belgium, Germany, France and Netherland. Peripheral Banks are banks from Greece, Italy, Ireland, Portugal and Spain. The dependent variable for the first stage regression is IRB% (DF), which indicates the % of IRB methodology upon exposure to a country (default frequency upon exposure to a country). Z1 (Z2) is the instrument variable for IRB% (DF), which indicates the % of IRB methodology upon exposure to all other countries (default frequency upon exposure to all other countries). The dependent variable for the second stage regression is RW, risk weight of exposure to a country. IVIRB% (IVDF) is the instrumented IRB% (DF) from the first stage regression. EAD: total ln(EAD) to a country. PRIVATE: the proportion of exposure to retail and corporate over total exposure. GOV: the proportion of exposure to central and regional governments over total exposure. SIZE: ln(total asset of bank). CAP: total equity / total asset. GIIPS is a dummy variable, which equals to 1 if the exposure is in one of the following countries: Greece, Italy, Ireland, Portugal and Spain. All variables are winsorized at 1st and 99th percentile. Standard errors are heteroscedasticity-robust and clustered at the Bank *x* Time level. ***, **, and * indicate significance at the 1, 5 and 10 percent levels, respectively. All country-portfolio level data are from EBA and all bank level variables are from Bloomberg.

	Core Banks			Peripheral Banks		
	First Stage		Second Stage	First Stage		Second Stage
Dep. Variable	IRB	DF	RW	IRB	DF	RW
	[1]	[2]	[3]	[4]	[5]	[6]
IVIRB			-0.1129**			-0.5311*
IVIRB * GIIPS			0.1834**			-0.0968
IVDF			1.7390**			4.8727
IVDF * GIIPS			-0.6141			0.5284
GIIPS	0.2268**	0.0233*	-0.1645*	0.1604	0.0019	0.2878**
z1	-1.1151***	0.0605***		-0.6422***	-0.0212	
z2	-1.0250**	-0.3098***		-3.2823***	-0.2751	
EAD	-0.0105**	-0.0005	-0.0348***	-0.0113	0.0107***	-0.1025
PRIVATE	0.1423***	0.0453***	0.1624***	0.3562***	0.0390***	0.4908***
GOV	-0.1170*	-0.0191***	-0.1557***	-0.0648	-0.0146	-0.3895**
SIZE	-0.1301	-0.0047	0.1614***	0.9143**	0.0667	0.2419
CAP	-2.0830*	-0.0622	2.1878***	3.5644	0.1606	1.9290
Bank FE	YES	YES	YES	YES	YES	YES
HomeCountry *x* Time FE	YES	YES	YES	YES	YES	YES
ExpCountry *x* Time FE	YES	YES	YES	YES	YES	YES
N	1624	1624	1624	467	467	467
Adj. R-Squared	0.58	0.47	0.61	0.64	0.78	0.63
Wald Test						
IVIRB			-0.1129**			-0.5311*
IVIRB*(1+GIIPS)			0.0705			-0.6279*
IVDF			1.7390**			4.8727
IVDF*(1+GIIPS)			1.1249			5.4011

Table 6 Regulatory Arbitrage under Shocks.

The purpose of this table is to identify regulatory arbitrage in the context of capital shocks (Panel A) macro shocks (Panel B). A few dummy variables are introduced, including: POORCAP, which equals to 1 if a bank's tier1 ratio is ≤10% but ≥8%; UNDERCAP, which equals to 1 if a bank's tier1 ratio is ≤8%. CRISIS, which equals to 1 if the exposed country is "in crisis" - only if a Euro country's bond spread (with respect to Germany) is above 400 basis points calculated as the average of daily bond spreads over the 3-month period preceding the observation date; STRESS, a dummy variable indicating those observations in which the home country of the bank is considered to be "in crisis" (400bps ≤ spread). The sample period is still the same as baseline - from end 2012 to mid-2016 on a near biannual basis (with one gap in mid-2014). The dependent variable and control variables are also the same as the baseline. All the other regression settings regarding, winsorization, error-clustering and coefficient significance are the same as previous table. For simplicity only part of the results are shown. All country-portfolio level data are from EBA and all bank level variable are from Bloomberg.

Panel A: Bank Specific Capital Shock

Sample Banks	Core Banks	Core Banks	Peripheral Banks	Peripheral Banks
	[1]	[2]	[3]	[4]
IVIRB	-0.1022*	-0.0993*	-0.5578*	-0.6279*
IVIRB*POORCAP	0.1047		0.0975	
IVIRB*UNDERCAP		(omitted)		0.4091
IVDF	1.7889**	1.7487**	4.6558	6.3890
IVDF*POOCAP	-0.7712**		0.2596	
IVDF*UNDERCAP		(omitted)		0.2180
POORCAP	-0.0107		0.0055	
UNDERCAP		(omitted)		-0.5265*
Country-Portfolio Controls	YES	YES	YES	YES
Bank Controls	YES	YES	YES	YES
Bank FE	YES	YES	YES	YES
HomeCountry *x* Time FE	YES	YES	YES	YES
ExpCountry *x* Time FE	YES	YES	YES	YES
N	1624	1624	467	467
Adj. R-Squared	0.61	0.61	0.63	0.63
Wald Test				
IVIRB*(1+POORCAP)	0.0025		-0.4603	
IVIRB*(1+UNDERCAP)		/		-0.2188
IVDF*(1+POORCAP)	1.0177		4.9154	
IVDF*(1+UNDERCAP)		/		6.6070

Panel B: Bank Specific Capital Shock

Sample Banks	Core Banks	Core Banks	Peripheral Banks	Peripheral Banks
	[1]	[2]	[3]	[4]
IVIRB	-0.1012*	-0.0993*	-0.5709**	-0.5669**
IVIRB*CRISIS	-0.2272		0.4346*	
IVIRB*STRESS		(omitted)		0.1561

IVDF	1.7620**	1.7487**	4.7994	4.7586
IVDF*CRISIS	-3.2980*		-0.3096	
IVDF*STRESS		(omitted)		0.3259
Crisis	0.3426		-0.0156	
Stressed		(omitted)		0.2957
Country-Portfolio Controls	YES	YES	YES	YES
Bank Controls	YES	YES	YES	YES
Bank FE	YES	YES	YES	YES
HomeCountry *x* Time FE	YES	YES	YES	YES
ExpCountry *x* Time FE	YES	YES	YES	YES
N	1624	1624	467	467
Adj. R-Squared	0.61	0.61	0.63	0.63
Wald Test				
IVIRB*(1+CRISIS)	-0.3284		-0.1363	
IVIRB*(1+STRESS)		/		-0.4108
IVDF*(1+CRISIS)	-1.5360		4.4898	
IVDF*(1+STRESS)		/		5.0845

Table 7. Evidence of Cherry-Picking.

This table provide evidence that some banks may strategically limit the use of IRB on certain exposures for capital saving purpose. Panel A shows the proportion of IRB exposure based on aggregated data of banks from the same country. Panel B shows the risk-weights for public exposures under SA, based on aggregated data of banks from the same country. Panel C shows the result of univariate regression of total risk weights (under both SA and IRB) of exposure to the public (private) sector on the proportion of IRB of exposure to that sector. All variables are winsorized at 1st and 99th percentile. Standard errors are heteroscedasticity-robust and clustered at the Bank *x* Time level. ***, **, and * indicate significance at the 1, 5 and 10 percent levels, respectively.

Panel A: Proportion of IRB exposure

Country of Exposure	Domestic	Non-US Foreign	US
Sector of Exposure	Public	Public	Public
Bank's Home Country	[1]	[2]	[3]
Austria	3.4%	6.7%	99%
Belgium	77%	60%	83%
Germany	32%	56%	94%
France	48%	79%	84%
Netherland	92%	92%	92%
Greece	0.0%	0.0%	/
Ireland	24%	48%	41%
Italy	0.1%	5.9%	39%
Portugal	0.0%	0.0%	/
Spain	2.3%	1.6%	4.8%
Denmark	0.0%	0.0%	0.0%
Finland	0.0%	0.0%	/
Norway	0.0%	0.0%	0.0%
Sweden	0.0%	0.0%	0.0%
UK	9.1%	67%	78%

Panel B: Risk-Weights under SA

Country of Exposure	Domestic	Non-US Foreign	US
Sector of Exposure	Public	Public	Public
Bank's Home Country	[1]	[2]	[3]
Austria	2.0%	2.9%	20.0%
Belgium	1.7%	8.2%	29.6%
Germany	1.0%	2.5%	17.6%
France	9.4%	17.3%	12.0%
Netherland	31.1%	15.1%	0.0%
Greece	0.3%	16.6%	#DIV/0!
Ireland	0.4%	1.1%	11.4%
Italy	13.9%	4.7%	2.1%
Portugal	1.9%	22.9%	#DIV/0!
Spain	5.0%	10.3%	10.0%
Denmark	0.0%	0.4%	0.0%
Finland	0.1%	0.0%	#DIV/0!
Norway	0.0%	0.0%	0.0%

Sweden	0.3%	0.4%	0.0%
UK	1.1%	4.9%	12.3%

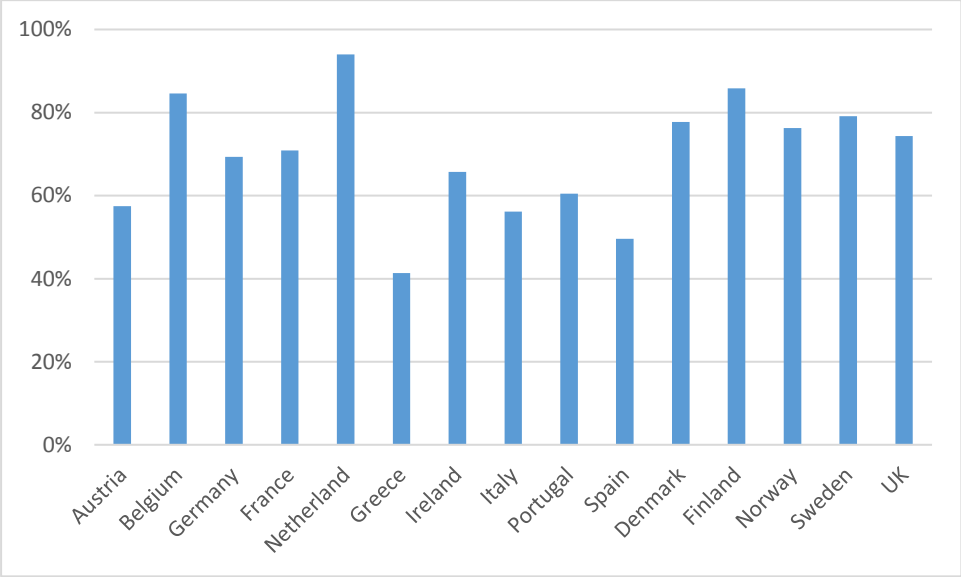
Panel C: Univariate Regression

Dep.Variable	RW_{total}	RW_{total}
Sector of Exposure	Public	Private
	[1]	[2]
IRB%	0.0830***	-0.3930***
Bank FE	YES	YES
HomeCountry *x* Time FE	YES	YES
ExpCountry *x* Time FE	YES	YES
N	2737	2737
Adj. R-Squared	0.51	0.65

Figure 1: Use of IRB approach

Each figure is based on the aggregated data of all banks from the same country. Finland and Norway only include one bank observation each (OP-Pohjola Group and DNB Bank Group respectively).

A. Total Portfolio, IRB%.



B. Private Sector vs. Public Sector, IRB%.

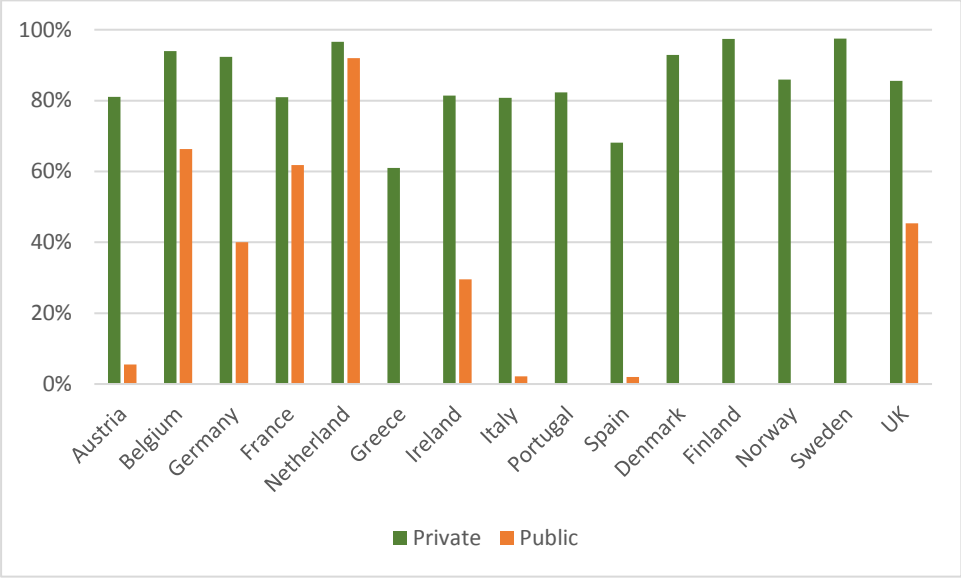
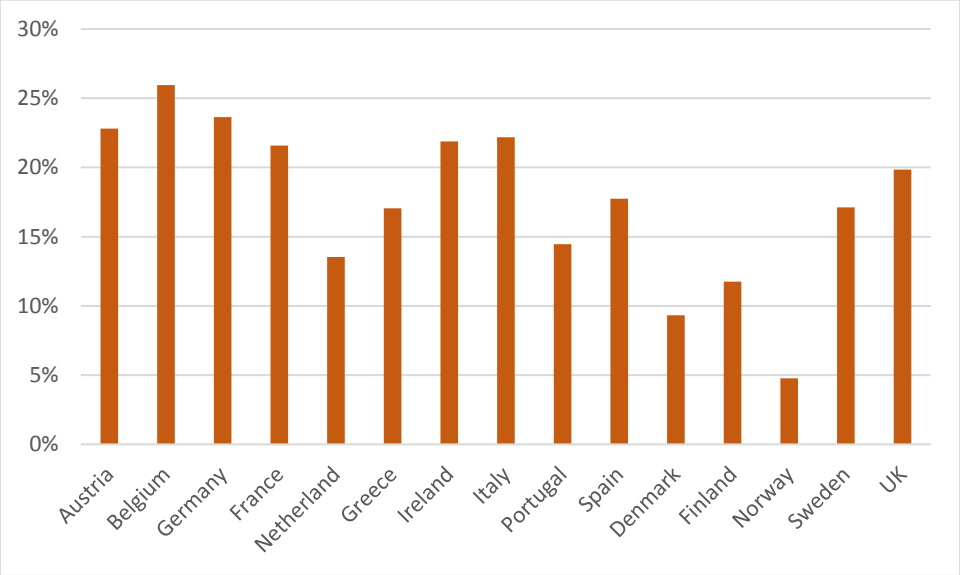


Figure 2: Proportion of public exposure

Each figure is based on the aggregated data of all banks from the same country. Finland and Norway only include one bank observation each (OP-Pohjola Group and DNB Bank Group respectively).



Annex 1 – Geographical Breakdown of Bank's Exposure

	Country of Origin of Banks															
Country of Exposure	AT	BE	DE	DK	ES	FI	FR	GB	GR	IE	IT	NL	NO	PT	SE	Total
Total	189	157	746	81	145	33	336	252	32	73	172	232	70	48	224	2790
Angola														5		5
Austria	19		54								7	2				82
Australia		2						4				14				20
Belgium	2	15	6	1			18	2			2	16				62
Bulgaria	2								6							8
Bermuda			2													2
Brazil					7			7				7				21
Canada		1	4			2		7					2			16
Switzerland	1		50	5			22	16				15				109
Cook Islands			7													7
Chile					14											14
China			3					10			4	1				18
Colombia					3											3
Channel Islands								2								2
Cyprus									3							3
Czech Republic	14	7					7				7					35
Germany	17	14	79	8	6	5	37	18		3	12	24	7		12	242
Denmark				15									7		21	43
Estonia															14	14
Spain	5	10	57		25		25	8		4	6	7		2		149
Finland				7		6						2	5		28	48
France	9	17	76	3	9	5	38	25		11	19	25	4	5	1	247
United Kingdom	14	17	77	8	13	5	36	28	1	15	16	21	7	5	23	286
GUERNSEY				2												2
Greece									6					2		8
Hong Kong								7				8				15
CROATIA	12										10					22
Hungary	14	7	3								3					27
Ireland	4	7	7	7				14		19		3		3		64
Isle of Man										1						1
India			2					1								3
Italy	5	10	44		6		33	7			30	3				138
International organisations							3	3								6
Japan		5					16	2								23
Korea Republic_of							4									4
Cayman Islands			7	2				4								13
Lithuania													7		14	21
Luxembourg		6	60	5	1	4	30	12	4	2	3	3	2	5	4	141
Latvia													3		14	17
Marshall Islands			13													13
Macedonia									1							1
Mexico					14			2								16

Mozambique															7		7
Netherlands	5	4	71				16	19		4	6	28				4	157
Norway		2	1	9		1						2	7			28	50
New Zealand												7					7
Other					2		2										4
Peru					7												7
Poland	14		12								7	10	5	7		5	60
Portugal		5	2		8									7			22
Romania	14		2				1		6								23
Serbia									2		1						3
Russian Federation	7		2				7				7					5	28
Saudi Arabia								6									6
Sweden			12	7		5							7			28	59
Singapore			2					7				7					16
Slovenia	3																3
Slovakia	14	5									7						26
Turkey			2		7		7		3		7	4					30
Ukraine	5																5
United States	7	17	75	2	18		33	28		12	18	19	7			23	259
Venezuela					5												5
VIRGIN ISLANDS, BRITISH								2				4					6
South Africa								7									7
Other Countries	2	6	14				1	4		2							29