UNIVERSITÀ DEGLI STUDI DI UDINE
hic sunt futura

Corso di dottorato di ricerca in

Scienze Manageriali e Attuariali

Ciclo XXXV

Titolo della tesi

Bank's capital structure and risk allocation after the introduction of ESG criteria in the financial sector

Dottorando

Egidio Palmieri

Supervisore

Prof. Maurizio Polato

Anno 2022/23

ABSTRACT

The thesis brings together three papers related to risk management in credit institutions. Each of them deals with aspects of risk management in banks arising from supervisory innovations introduced by the regulator. In recent years, regulatory innovations have been numerous and have profoundly influenced the banking sector. In this thesis we initially deal with the introduction of Total Loss Absorbing Capacity (TLAC) requirements for Global Systemic Important Banks (G-SIBs). This capital requirement has been introduced in order to reduce the existence of contagion effects within the banking and financial system. Moreover, the introduction of the loan origination and monitoring guidelines (LOM) by the European Banking Authority (EBA) highlighted the importance of ESG topics within the credit granting process. This process of integrating ESG issues into banks' risk management can have effects: (i) indirect, when ESG performance impacts companies in banks' loan portfolios; (ii) direct, when improvements in ESG scores have direct effects on banks' riskiness and profitability. Therefore, the second article is structured to analyze the implications in terms of risk mitigation following indirect improvements in ESG scores. The third paper, on the other hand, analyses the direct risk mitigation effects on financial institutions.

More specifically, the first paper explores the impact on G-SIBS' capital requirements following the introduction of TLAC by the Financial Stability Board (FSB) in 2015. We have divided the effects into microeconomic and macroeconomic impacts. The former is related to individual banks, while the latter consider the entire financial system as a whole. Through a market analysis, we have highlighted the need for G-SIBs to strengthen their capital endowment, mediating the use of instruments such as senior non-preferred bonds (SNPB). The higher cost of raising funds could lead to an increase in the price of loans and a credit contraction.

The second paper is empirical in nature and tries to answer the following two research questions (i) RQ1: To what extent do ESG individual pillars contribute to reducing firms' default probabilities?; (ii) RQ2: How ESG risk mitigation effect is amplified d or

reduced by the sector firms belong to? Using a sample of 335 European listed companies, we have quantified and demonstrated the existence of an indirect risk mitigation effect on listed companies. In addition, we have provided evidence of how much and to what extent the sector contributes to the risk mitigation effect mentioned above.

The third paper deals with the direct effects of ESG performance on the risk and return profile of credit institutions. In addition to what has already been observed in the literature, the new element is the use of cluster analysis to define a set of dummies expression of the banks' business model. We have proved empirically that the investing activities, retail, and wholesale business models are able to present a direct ESG risk mitigation effect with a confidence level of 99%. Finally, regarding profitability, we observe that governance performance produces value for banks' stakeholders, while the other pillars significantly affect stockholders.

Systemic risk and capital safeguards: characteristics and impacts of Total Loss Absorbing Capacity (TLAC)

E.F. Geretto ♠, E. Palmieri ♣

Corresponding author: Egidio Palmieri Department of Economics and Statistics, University of Udine, Italy, Address: Udine, Via Tomadini 30/A, Phone: +39 342 0556986,

email: palmieri.egidio@spes.uniud.it

Abstract

The Financial Stability Board (FSB) in consultation with the Basel Committee, in order to reduce the systemic risk and limit the contagion effect between institutions, in November 2015 introduced a new regulatory requirement applicable only to G-SIBs: Total Loss-Absorbing Capacity. The aim of this work is to try to identify both the impacts of a microeconomic nature, borne by the individual institutions subjected to them and those of macroeconomic nature, which can be found within the system as a whole. For these purposes, the next paragraph examines the TLAC and defines its characteristics, followed by an analysis of senior non-preferred bonds, relating to the reasons for their provision and the connections with the new requirement. Paragraphs 4 and 5 deal respectively with the results from some market analysis and the possible impacts resulting from the introduction of the TLAC. Finally, some brief concluding remarks are discussed.

The data processed show how the introduction of measures aimed at reinforcing the sources to be used in the event of failure of systemically important banks increases the need for funds to be used in this regard, with a possible increase in the cost of funding and probable repercussions on the pricing of loans: this should lead to a more conscious

♠ University of Udine. Department of Economics and Statistics. Via Tomadini 30A – 33100 Udine. E-mail: palmieri.egidio@spes.uniud.it.

♣ University of Udine. Department of Economics and Statistics. Via Tomadini 30A – 33100 Udine. E-mail: enrico.geretto@uniud.it.

assumption of risks and, in general, to a more strict observance of the principles of sound and prudent management, especially in terms of the development of business volumes.

1. Introduction

The work aims to analyze the potential impacts deriving from the adoption of TLAC (Total Loss-Absorbing Capacity) by global banking institutions on banks' capital endowment (so-called G-SIBs - Global Systemically Important Banks): this qualification is attributed to banks which satisfies dimensional, interconnection, operational complexity, and significance profiles of cross-border activities, defined by the Basel Committee (BCBS, 2018).

The Great Financial Crisis of 2007 highlighted the precarious stability of the global financial system and the difficult management of crises affecting large intermediaries: in particular, the bankruptcy of this type of institutions revealed how the systemic contagion effect can trigger spill over phenomena with severe consequences. Two factors that facilitate the propagation of a crisis, originated in a specific geographical area, can be identified in financial markets integration and interdependence: these conditions have made it possible to transfer the effects of "liquidity and trust" crisis between counterparties, which occurred in 2007 in the American interbank market and spread in numerous other countries and economies (Masera, 2009).

The management of a crisis which involve any financial intermediary raises the problem of identifying the subjects who will have to bear any losses. In this regard, there are two possible strategies, and they differ according to those who will bear the negative economic results:

- bail-in, losses are charged to the bank's stakeholders (shareholders; creditors; depositors)
- bail-out, involvement of external subjects (Jiangping et al., 2013). In this circumstance it is the State that provides the bank in difficulty with economic aid, putting the cost of the crisis on taxpayers.

The recent regulatory provisions issued by supervisory authorities identify in the bail-in mechanism the process to be mainly used in the face of bank failures, as it allows to increase the responsibilities of the management bodies, or to overcome unvirtuous practices, often carried out by larger financial institutions (so-called too big to fail - TBTF). These typically rely on the historic propensity of states to rescue them, through public aid in order to avoid repercussions on the local economy, which would have been generated as a result of the bankruptcy of the institution (IMF, 2017). This behavior led to moral-hazard phenomena on the part of the top management, who, with the growth of the bank's size, could have oriented their business on investing on risky activities, characterized by higher rates of return (Brierley et al., 2017). Management, incentivized by bonuses directly proportional to the economic results achieved and not penalized by the assumption of positions inconsistent with the institution target profile risk, has led numerous intermediaries to take risks to an extent that is not compatible with principles of sound and prudent management and in any case unsustainable in a medium-long term perspective. In this context, the bail-in, by internally identifying the subjects called to respond in the first instance for losses, leads to strong accountability of the top management bodies (Sironi, 2018).

The Financial Stability Board (FSB) in consultation with the Basel Committee, in order to reduce the systemic risk and limit the contagion effect between institutions, in November 2015 introduced a new regulatory requirement applicable only to G-SIBs: Total Loss-Absorbing Capacity. The aim of this work is to try to identify both the impacts of a microeconomic nature, borne by the individual institutions subjected to them and those of macroeconomic nature, which can be found within the system as a whole. More specifically, we contribute to the existing literature enlightening that the efforts to bolster the resources available in case of failure of systemic banks increase the requirement for funding, potentially driving up the cost of funding and influencing loan pricing. This may result in heightened awareness of risks and stricter adherence to sound and prudent management principles, particularly in regard to business growth. For these purposes, the next paragraph examines the TLAC and defines its characteristics, followed by an analysis of senior non-

preferred bonds, relating to the reasons for their provision and the connections with the new requirement. Paragraphs 4 and 5 deal respectively with the results from some market analysis and the possible impacts resulting from the introduction of the TLAC. Finally, some brief concluding remarks are discussed.

2. TLAC definitions and characteristics

TLAC is an additional capital requirement in respect to Basel 3 provisions, applicable only to G-SIBs. Its introduction aims at strengthening the capital endowment of subjected banks, in order to increase their loss-absorbing capacity: in this way, greater stability of the financial system would be guaranteed, and the existing systemic risk would be reduced. It should be remembered that the G-SIBs are institutions that meet a series of criteria of various kinds (e.g.: size, interconnection, etc.).

The identification of these institutions takes place through the application of a scoring mechanism based on five variables (Table 1): each of them has an impact of 20% on the final indicator. Depending on the number of parameters (defined in terms of 'calculation bases') available for each variable, the percentage weight of each of these is equally divided (for example, the variable "international operations" which has two 'bases of calculation', attributes a weight of 10% to each of them). From the result deriving from the application of the algorithm, we obtain the allocation of the single institution within a specific bucket (or 'membership category').

Table 1: Percentage incidence of variables in G-SIBs scoring indicator

Variables	**Impact**	**Individual indicator**	***Scoring* weight**
Cross-jurisdictional activity	20%	Cross-jurisdictional claims Cross-jurisdictional liabilities	10%
		Cross-jurisdictional claims Cross-jurisdictional liabilities	10%
Size	20%	Total exposures as defined for use in the Basel III leverage ratio*	20%
Interconnectedness	20%	Intra-financial system assets* Intra-financial system liabilities* Securities outstanding*	6,67%
		Intra-financial system assets* Intra-financial system liabilities* Securities outstanding*	6.67%
		Intra-financial system assets* Intra-financial system liabilities* Securities outstanding*	6,67%
Substitutability/financial institution infrastructure	20%	Assets under custody and payments activity	6,67%
		Underwritten transactions in debt and equity markets	6,67%
		Trading volume	3,33%
		Underwritten transactions in debt and equity markets	3,33%
Complexity	20%	Notional amount of over the counter (OTC) derivatives*	6,67%
		Level 3 assets*	6,67%
		Trading and available-for-sale securities	6,67%

Source: own elaboration on data found in (BCBS, 2018)

For institutions that belong to bucket 1 or higher (i.e., that achieve a dimensional scoring score greater than 129), the obligation to comply with the TLAC requirement applies (Table 2).

Table 2: Bucket definition and CET1 requirement

Bucket	**Score**	***CET* 1 additional indicator**	**Subject to *TLAC***
5	530–629	3,5%	Yes
4	430–529	2,5%	Yes
3	330–429	2,0%	Yes
2	230–329	1,5%	Yes
1	130–229	1,0%	Yes
None	<130	0%	No

Banks subject to *TLAC*

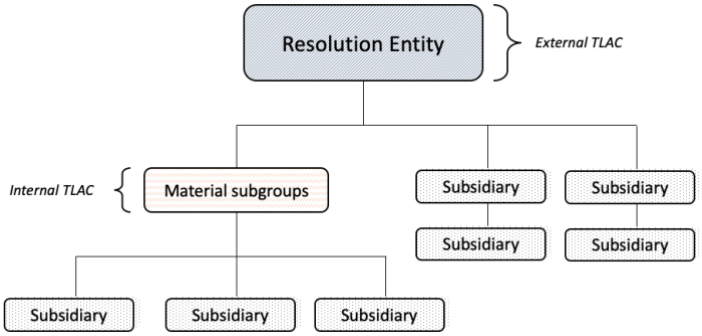
Source: own elaboration on data found in (BCBS, 2018)

The new capital requirement is divided into external TLAC and internal TLAC. The first, can be applied to each resolution entity of a G-SIBs and it is calibrated according to the consolidated balance sheet of the single resolution group (Speyer, 2015). In this optic, the external TLAC represent the capital endowment, made up by loss-absorbing resources, that belongs to the resolution group as a whole. The resolution entities are represented by the subjects to whom the resolution tools are applied in compliance to the relative strategy envisaged by the singular G-SIBs: in general, they are identified in holding, intermediate companies, parent companies or controlled. The resolution entities, together with any other controlled entity, directly or indirectly, form the so-called 'Resolution group' (Tröger, 2019). The internal TLAC, on the other hand, is applied only to "material" subgroups, or business combinations that:

- they do not constitute resolution entities;
- they are not part of another material sub-group of the G-SIBs;
- fall under the same jurisdiction as the resolution entity to which are submitted;
- meet the so-called 'Materiality criterion', namely:
    - own more than 5% of the G-SIBs' consolidated RWAs;
    - generate more than 5% of the operating income of the G-SIBs;
    - present an exposure measure - EM (denominator of Leverage Ratio required by the Basel 3 regulation) higher 5% of that referred to the entire G-SIBs;
    - are identified by the Crisis Management Group (CMG) as entities who perform essential functions for the exercise of the intermediary's business, and which are intended to be safeguarded through an orderly resolution process (FSB, 2011a).

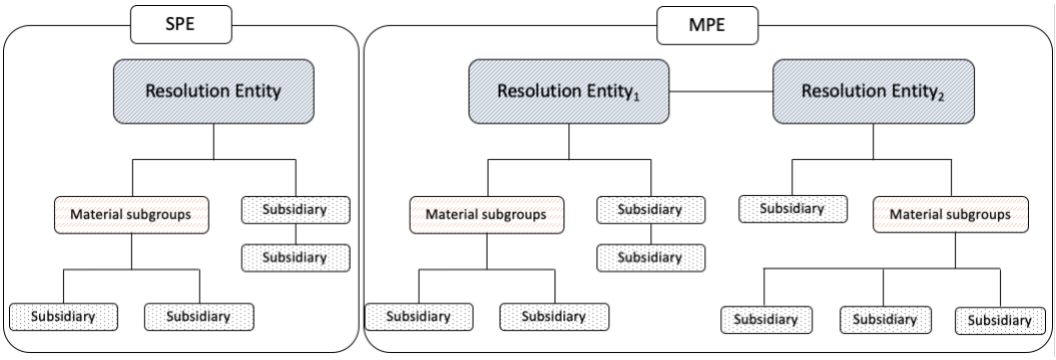
For explanatory purposes, a graphic representation (Figure 1) of the application criteria of the external and internal TLAC is proposed.

Figure 1: *Internal/External TLAC* Application



The figure above shows one of the two resolution strategies (called SPE - Single Point of Entry) that can be adopted by a G-SIBs for the distribution of resolution powers, relating, for example, to the application of the bail-in and the intra-group transfer of TLAC eligible instruments (Gortsos, 2019). This method provides resolution powers to a single subject, usually the parent company. As an alternative to the mechanism described, the so-called "Multiple Point of Entry" (MPE), in which resolution powers are shared between two or more resolution entities. In this case, the group is divided into multiple resolution entities according to the geographic area, business lines, or a combination of these two parameters. Powers are not necessarily attributed equally: resolution strategy could weigh more one resolution entity than another, due to the importance of the activities carried out by its subsidiaries. The following figure outlines the differences between the Single Point of Entry and Multiple Point of Entry strategies.

Figure 2: *SPE* and *MPE* strategies comparison



The minimum external TLAC indicator is calculated by applying the coefficients ΔRWA and ΔEM respectively to the group risk weighted assets (RWAs) and the exposure measurements (EM). The legislation provides that both coefficients will be gradually raised, up to a level of full capacity, following the times shown in Table 3.

Table 3: external TLAC coefficients

Coefficients	2019	2022
α_{RWA}	16%	18%
α_{EM}	6%	6,75%

G-SIBs based in emerging markets must make the first adjustment of both ratios by January 2025 and the second by January 2028: this time delay could accelerate if the volume of corporate debt securities issued reaches at least 55% of the GDP of the reference emerging economy.

The minimum external TLAC represents an extension of the capital requirements envisaged by the Basel agreements: it follows that the adjustments to this indicator must be calculated net of provisions already made for Tier 1 purposes. In this regard, consider the hypothetical situation of an institution whose Tier 1 ratio is equal to 8% of RWAs and which, to comply with the new capital absorption forecasts, must set aside 18% of RWAs and 6.75% of EM (Gianmattei et al., 2010).

The contribution of equity instruments and other liabilities (equal to ΔC) for TLAC purposes is derived as follows:

(1) $$\Delta C = (18\% * RWA + 6{,}75\% * EM) - TIER\ 1$$

More generally:

(2) $$\Delta C = (\alpha_{RWA} * RWA + \alpha_{EM} * EM) - 8\% * RWA$$

It is possible to split the two distinct capital requirements imposed by the TLAC as follows:

(3) $$\Delta C_{RWA} = (\alpha_{RWA} * RWA) - 8\% * RWA = (\alpha_{RWA} - 8\%) * RWA$$

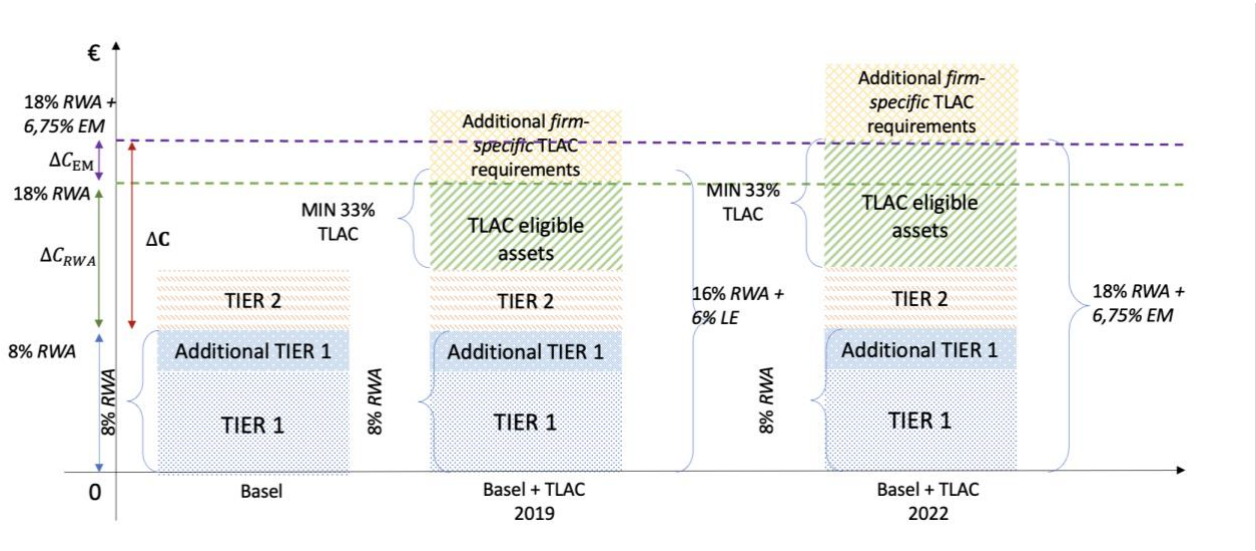
(4) $$\Delta C_{EM} = \alpha_{EM} * EM$$

From which:

(5) $$\Delta C = \Delta C_{RWA} + \Delta C_{EM}$$

The resulting graphic representation is the following:

Figure 3: *Minimum External TLAC requirement*



Banking regulation also dispone that the TLAC-eligible liabilities (not already included in the regulatory capital) constitute an amount at least equal to 33% of the minimum TLAC requirement: in this way it is possible to avoid that Tier 2 and additional Tier 1 components constitute a substantial part of the instruments used to comply with regulatory provisions. The resolution authorities are also given the power to impose on individual G-SIBs an additional firm-specific requirement for both the external and the internal TLAC.

ΔCRWA value is obtained by subtracting the minimum capital requirement required by the Basel provisions from the minimum External TLAC; ΔCEM instead represents the fraction of ΔC to cover the greater risks associated with the increase in the level of leverage.

In this regard, all the instruments admitted for Tier 1, Tier 2 and the liabilities that can be subscribed or converted into equity during the resolution process of the G-SIBs can be used, without compromising the performance of the main functions of the institution and avoiding the emergence of legal disputes or requests for compensation (Pwc, 2014). The characteristics of the instruments that can be used for eligibility purposes have been defined by the Financial Stability Board (FSB), which states that they must:

- be already paid;
- not be guaranteed;
- not be subject to offsetting rights that would compromise the ability to absorb losses in the event of resolution;
- have a minimum residual contractual duration of at least one-year o perpetual (i.e. without expiration);
- be non-refundable by the holder before the deadline;
- not be issued by a resolution entity (or part of it correlated) except for cases in which the authorities present in the CMG allow the recurrence of such circumstances.

However, the following instruments are deemed inadmissible:

- unsecured deposits;
- sight and short-term deposits;
- liabilities deriving from derivative contracts;
- debt instruments to which derivative contracts are connected (e.g.: structured notes);
- liabilities not deriving from contracts (e.g.: tax liabilities);
- liabilities with a higher degree of pre-emption than senior unsecured creditors;
- any liability which, by the regulatory provisions of the issuing country, cannot be subject to bail-in, or which cannot be subscribed or converted into equity by the resolution authority, without incurring legal disputes or legitimate compensation claims.

Furthermore, the set of instruments that do not comply with the "no creditor worse off principle " cannot be considered suitable: this means that, in the resolution phase, the creditors of the institution must not bear losses greater than those which they would be

charged to them in an orderly liquidation process. The instruments allowed, if necessary, will be used following a succession dictated by the hierarchical order indicated by the BRRD (Bank Recovery and Resolution Directive). In this regard, it is envisaged that the first subjects required to respond for losses are the shareholders and only subsequently the various types of creditors of the institution: to protect the counterparties deemed worthy of protection, investors, and depositors (Directive 2014/59/UE).

The tools created for TLAC purposes may however present problematic aspects related to the usage of complex structures. For example, the provision of call clauses guarantees flexibility and opportunities for institutions. On the other, the existence of this tools undermines the predictability of the bail-in site. This aspect becomes central in MPE resolutions and in those involving G-SIBs with a strong vocation for cross-border operations, generating doubts and conflicts in the clear and unambiguous identification of creditors hierarchy (Clerc, 2015). Considering regulation differences between jurisdictions, it is possible to note how *pari passu* loans, for which all holders must be subjected to an identical degree of loss support, increase the risk for the intermediary of incurring legal disputes and requests for reimbursements (Fernandez et al, 2015). A further obstacle of a regulatory nature arises from the restriction on the exchange of eligible TLAC instruments issued in foreign countries, as these are free to limit access to investors, favoring the satisfaction of local creditors, instead of non-resident ones. To avoid such situations, host countries must guarantee that the legal system can standardize the regulatory differences existing with the countries of origin, without creating distortions in the conduction of business within the market among domestic and local intermediaries as well as foreign ones (Colucci, 2018). A probable consequence is identified in the possibility that the obligations contracted for the purpose of complying with the TLAC take on the role of a 'barrier' to the dimensional growth of the institutions, which, in order not to run into higher capital requirements, will tend to avoid exceeding the threshold values set for the G-SIBs.

Furthermore, Hasenclever C., (2020) identify in the minimum TLAC and MREL requirement a challenge for bank management: looking for an optimal resolution strategy

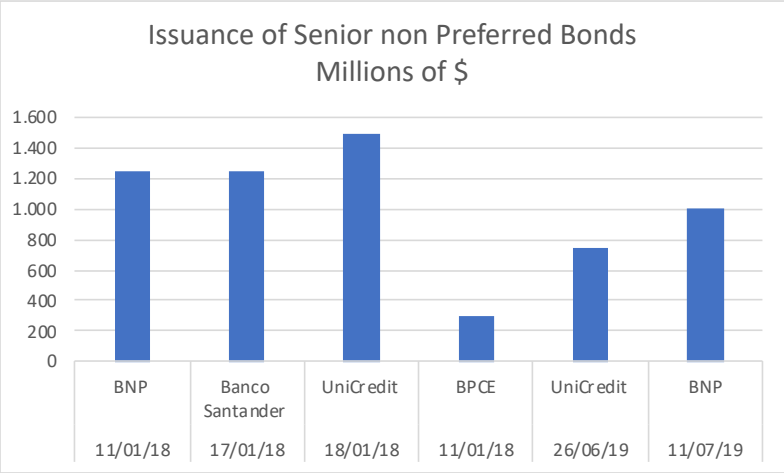
and a coherent balance sheet there is a tradeoff among prudent funding strategy and costs reduction.

Bank of Italy in a post-Covid study enlighten the existence of two kind of "bad investors" during the resolution process of a G-SIB: households and hedge funds. The former owns more households' holdings when they present low levels of financial literacy. The latter acts procyclical and with a limited role (Bank of Italy, 2021).

3. A new category of eligible instruments: *senior non-preferred bonds*

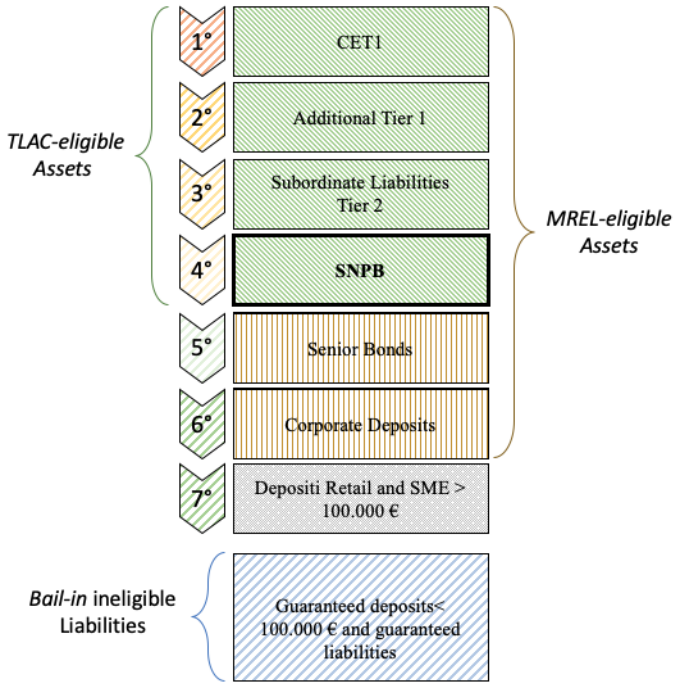
The main objective of TLAC is to ensure that troubled G-SIBs have sufficient loss-absorbing and recapitalization capacity, in order to minimize the impact of any bank failure on the financial system. To achieve this purpose, the subjected institutions are required to have an appropriate amount of liabilities to cover losses, which can be converted into equity in the event of bank insolvency. The variety of bailable instruments once made up exclusively of regulatory capital (Tier 1 and Tier 2), junior unsecured and senior unsecured subordinated bonds, is expanded through the admissibility of the so-called senior non-preferred bonds - SNPB (Yap et al, 2017). This category of securities, introduced by the BRRD, is placed in a hierarchical position of satisfaction of creditors, intermediate between junior subordinated liabilities and senior debt (Directive 2017/2399/UE). In the following picture is it possible to observe the most relevant of senior non-preferred bonds.

Figure 4: Issuance of Senior non-preferred Bonds.



The following figure shows the set of tools available to the resolution authorities and the respective order of use. Each class of instruments cannot be activated until the hierarchically preceding one is exhausted: this sequential order is indicated in the figure by the cardinal numbers corresponding to each category of liabilities. As can be seen, SNPB regulation allows, on the one hand, to strengthen the capital endowment of G-SIBs and, on the other, to establish an additional buffer to protect investors in senior bonds.

Figure 5: Hierarchical order of liabilities absorption



To be classified as an SNPB, a bond must meet the following general criteria:

- the minimum original contractual duration must be at least one year;
- be devoid of clauses representing derivative contracts and not itself a derivative;
- express within the contractual documentation and any prospectus the belonging to the class of SNPB instruments and the relative priority in the bail-in process.

It should be noted that, in addition to these requirements, the new category of instruments must comply with the eligibility conditions set out in the previous section. The subordination must be presented by this class of liabilities can be traced back to three possible cases:

- contractual, when it can be inferred from the contractual documentation;

- statutory, in the event that the regulatory framework of the issuing country provides for the subordination of the instrument;
- structural, if it is the structure of the institution that defines its subordination (only a holding company can issue SNPBs).

These three modes of subordination are not mutually excludable and, consequently, can manifest themselves simultaneously.

4. Market Analysis

TLAC implementation process is not uniform globally, both in terms of time and in terms of calibration of the indicator. Depending on the geographic area of reference, the full implementation of the new standard will take place according to the timing and according to the measures indicated below.

Table 4: External TLAC Calibration

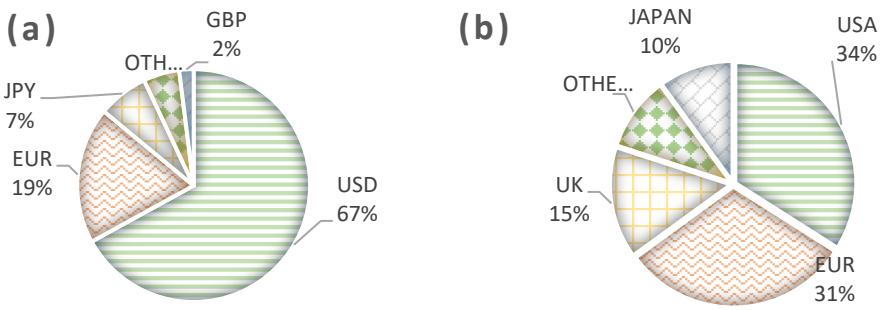
	2019		2020		2021		2022	
	α_{RWA}	α_{EM}	α_{RWA}	α_{EM}	α_{RWA}	α_{EM}	α_{RWA}	α_{EM}
Canada					18%	6,75%		
China	16%	6%					18%	6,75%
Japan	16%	6%					18%	6,75%
Switzerland			18-22,3%	6,75-8%				
UK	16%	6%			16%	6%	18%	6,75%
EU Banking Union	16%	6%					18%	6,75%
USA	18%	7,5%						

Legend: = temporary calibration = definitive calibration

The first countries to adopt the indicator at full capacity are United States, Switzerland and Canada. As you can see, the USA applies an ΔEM almost one percentage point higher than all the other countries considered (the ΔRWA coefficient has already been set at 18% since 2019). The result is an expectation that the TLAC eligible tools are, in the initial stages of implementation of the requirement, mainly denominated in dollars. In this regard, Figure 6 (a) highlights the currency areas and markets most interested in the

adaptation of G-SIBs to the TLAC: it is observed that two-thirds of the issues are expressed in dollars and only 19% in euros. The total weight of all other currencies does not exceed 14% globally. This phenomenon is also attributable to the imposition on American G-SIBs of minimum external TLAC coefficients higher than those of other countries (Switzerland alone constitutes an exception in this regard). Although 67% of the instruments are denominated in dollars, only 34% of the issuing institutions are American (Figure 6 b): it can be deduced that many non-US institutions have recourse to TLAC-eligible liabilities expressed in dollars rather than in currency local. This phenomenon is probably due to the greater ease of placing instruments with this kind of characteristic.

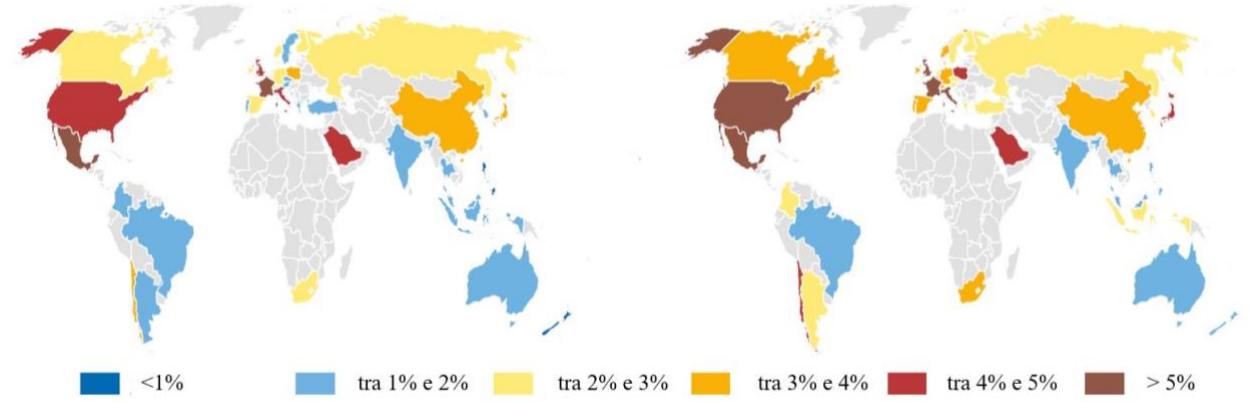
Figure 6: (*a*) *TLAC emission assets for currencies* (% of total) and (*b*) TLAC eligible liabilities issuing *G-SIBs geographical distribution*



A 2015 analysis studied the global distribution of macroeconomic costs related to the introduction of TLAC, expressing its effects in terms of percentage of annual GDP reduction (BCBS, 2015a). The reference period is twofold: the first considers the first two years from the introduction of the regulatory provision, while the second evaluates a longer period (4 years). The greatest impacts (i.e. greater than 5%) are produced by the US and European economies: otherwise, the least developed countries, due to slower adjustment times, have less intense GDP reduction rates (<2 %). These contractions in GDP are due to the tightening of the cost of funding which in turn generates a rise in interest rates on loans, which penalizes consumption and private investments. The result of this concatenation of effects materializes in the reduction of the gross domestic product of the individual countries: the

various types of interconnections existing between them accentuate the final negative effect[2].

Figure 7: TLAC impact on Worldwide GDP (2015-2019)



Two year from implementation Four year from implementation

Source: (B.I.S., 2015)

A coeval study (2015), aimed at evaluating the microeconomic impacts, carried out an analysis following the adoption of the TLAC on a sample of 26 G-SIBs: the data collected are shown in the following table (BCBS, 2015b).

Table 5: *external TLAC implementation process (% of accomplishment in November 2015*)

External TLAC	***Case 1***	***Case 2***
External TLAC risk-based	**14,1%** (13,1%)	**18,6%** (18,5%)
G-SIBs under 16%	20	11
G-SIBs under 20%	23	14
External TLAC EM	**7,2%** (7,2%)	**9,0%** (8,7%)
G-SIBs under 6%	12	5

Source: (BCBS, 2015)

[2] "The macroeconomic costs of TLAC are computed by translating the microeconomic impact of higher cost of the G-SIBs' liability structure to equivalent increases in G-SIB revenue through higher lending rates. These higher costs of credit to bank clients are then translated into lower levels of annual GDP. The calculation is based on three ingredients: the estimated increases in lending rates described above, the market shares of affected institutions, and the "multipliers", namely the estimated negative impact on GDP corresponding to an increase in lending rates. The methodology mirrors the one used in the BIS-FSB Macroeconomic Assessment Group for Basel III (MAG) study. " (BCBS, 2015a).

Case 1 provides evidence of the size of external TLAC, for the sample considered: this group includes in the calculation only the instruments admitted, unlike case 2, which incorporates the near-eligible TLAC liabilities: the value of the indicator for G-SIBs based in emerging markets is shown in brackets. In the first scenario, the requirement for external TLAC is not completely satisfied, falling below the minimum required as a percentage of RWAs (16%) for 20 institutions and below 20% for 23 G-SIBs. The number of banks, which do not comply with the minimum level, drops to 11 and 14 respectively in the hypothesis in which near-eligible TLAC liabilities are considered. Only 12 institutions in the first case and 5 in the second, do not meet the minimum requirement related to the exposure measure (EM). Finally, it can be observed that if the G-SIBs of emerging countries are included, all indicators suffer a decline, a phenomenon mainly due to the length adjustment times granted by the regulator. If we evaluate the sample in terms of shortfall in absolute value, we obtain the following representation.

Table 6: *External TLAC shortfall* (November 2015)

External TLAC shortfall	***Case 1***	***Case 2***
16% RWA or 6% EM + emerging markets	€ 767 bln	€ 526 bln
18% RWA or 6% EM + emerging markets	€ 1.110 bln	€ 773 bln
20% RWA or 6% EM + emerging markets	€ 1.388 bln	€ 1.025 bln
16% RWA or 6% EM	€ 498 bln	€ 260 bln
18% RWA or 6% EM	€ 755 bln	€ 422 bln
20% RWA or 6% EM	€ 949 bln	€ 588 bln

Source: (BCBS, 2015)

The table shows a not negligible increase in the deficit of external TLAC, in the event that institutions established in emerging markets are also considered among the G-SIBs. They have limited availability of admissible liabilities since ordinary deposits are the main source of funding: the result is a higher shortfall level than banks established in developed countries. Including the near-eligible TLAC liabilities, a significant reduction in the indicator under consideration is again noted.

Please note that the internal TLAC, as required by the FSB, must be in the range of 75% - 90% of minimum external TLAC, required from the G-SIBs if a resolution body is identified in itself. In this regard, the following table is presented.

Table 7: *internal TLAC implementation process (% of accomplishment in November 2015*)

Internal TLAC ratio	***Case 1***	***Case 2***
Internal TLAC risk-based	**17,5%**	**27,2%**
*G-SIBs < 75% del 16% * RWA*	1	1
*G-SIBs < 90% del 20% * RWA*	8	6
Internal TLAC leverage ratio	**6,8%**	**10,5%**
G-SIBs < 75% del 6%	3	2
G-SIBs < 90% del 6%	5	3
Internal TLAC shortfall	***Case 1***	***Case 2***
*75% of 16% * RWA requirement*	€ 7 bln	€ 6 bln
*90% of 20% * RWA requirement*	€ 54 bln	€ 31 bln
*75% of 6% * EM requirement*	€ 6 bln	€ 3 bln
*90% of 6% * EM requirement*	€ 19 bln	€ 9 bln

Source: (BCBS, 2015)

Case 1, as for the previous tables, is distinguished from the second by a lack in computing near-eligible TLAC liabilities. In both cases, only one institution fails to meet the minimum requirement of 75% of 16% of RWAs. If we consider a coefficient of 90% for the internal TLAC (compared to 20% of the RWAs) only 8 institutions (in the first case) and 6 (in the second) meet this criterion. As for the internal TLAC compared to the exposure measure, there is a greater number of banks able to comply with the relevant requirement. If for external TLAC shortfall the admissibility of near-eligible liabilities reduces the extent of the related requirement, for internal TLAC this effect is limited to the respect of only the component connected to the EM.

5. Potential impacts resulting from the adoption of TLAC

To analyze and measure the impacts generated by the adoption of TLAC it is necessary to separate the microeconomic effects from those of a macroeconomic nature. The former relates to the impact of the new requirement on the main economic and equity aggregates and the strategies of the G-SIBs; the latter considers how such adjustments could affect global economies.

In order to have sufficient resources to satisfy the minimum requirements imposed by the new regulatory provision, the institutions will have to increase the volumes of issues of TLAC-eligible liabilities, the cost of which, also due to the constraints of subordination envisaged for the SNPBs will be higher than for other forms of debt. This, in order to keep profits unchanged, could lead to a rise in lending rates to be applied to borrowing customers.

In order to verify the aforementioned hypothesis, a sample of 26 banks was analyzed (in this regard the list of G-SIBs drawn up by the FSB was used): the relative data were obtained from the Bloomberg platform for years running from 2013 to 2018 (surveys at 31 December). The following banks were excluded from the overall list produced by the FSB (due to missing data): Agriculture Bank of China; China Construction Bank; Royal Bank of Canada; Toronto Dominion. The values expressed in currencies other than the euro have been converted at the exchange rate referring to 31.12 of the same year, with figures indicated in millions of euros. Subsequently, the sample was reclassified by geographical area, in order to provide evidence of any anomalies and peculiarities connected to a specific individual economy. Then, the territorial subdivision used (Table 8). Due to the diversity of values found and for ease of interpretation of the proposed analyzes, the European banks have been divided into two distinct groups (EU1 and EU2).

The trend in interest expense shows an increasing trend for banks located in the United States, China, Japan, Europe 1 (Figure 8), and decreasing for the G-SIBs belonging to the Europe 2 and United Kingdom sample. It is emphasized by the effects of Quantitative Easing (QE), launched in 2014 by the ECB, with a certain probability can justify findings

observed for the Europe 2 sample. As is known, this is an unconventional monetary policy tool, which consists of the monthly purchase of large quantities of financial assets (e.g.: government bonds; asset-backed securities; covered bonds; high-rated corporate bonds; etc.), by issuing new money. The increase in the monetary base, together with the reduction in the yields of government bonds (effect deriving from the purchase of the same by the ECB) produces, on the one hand, the lowering of the debt repayment for market operators and, on the other hand, stimulates investment and inflation (Kandrac et al., 2017). Attached (Appendix 1) is the summary table of the changes recorded in the interest expense values for the individual banks of the entire sample.

Table 8: G-SIBs sample geographical distribution

EU1	Credit Suisse Deutsche Bank Banco Santander	CHINA	Bank of China Ind. & Com. Bank China
EU2	UBS BNP Credit Agricole Groupe BPCE ING Société Générale UniCredit	JPN	Mitsubishi Mizuho Sumitomo
UK	Barclays HSBC Holding Standard Chartered	USA	Bank of America Bank of NY Mellon Citigroup Goldman JPM Morgan Stanley State Street Wells Fargo

The increase in the cost of funding has led the G-SIBs to raise the lending rates charged to customers, to overcome the decrease in the economic margin deriving from the brokerage activity. As noted for interest expenses, for American, Chinese, European (group 1) and Japanese G-SIBs, the interest income recorded an increase: the exceptions are constituted, also in this case, by EU2 and UK (for details see Appendix 2).

Figure 8: Interest expense according to geographical area, 1.000€ as unit of measure (2013-2018)

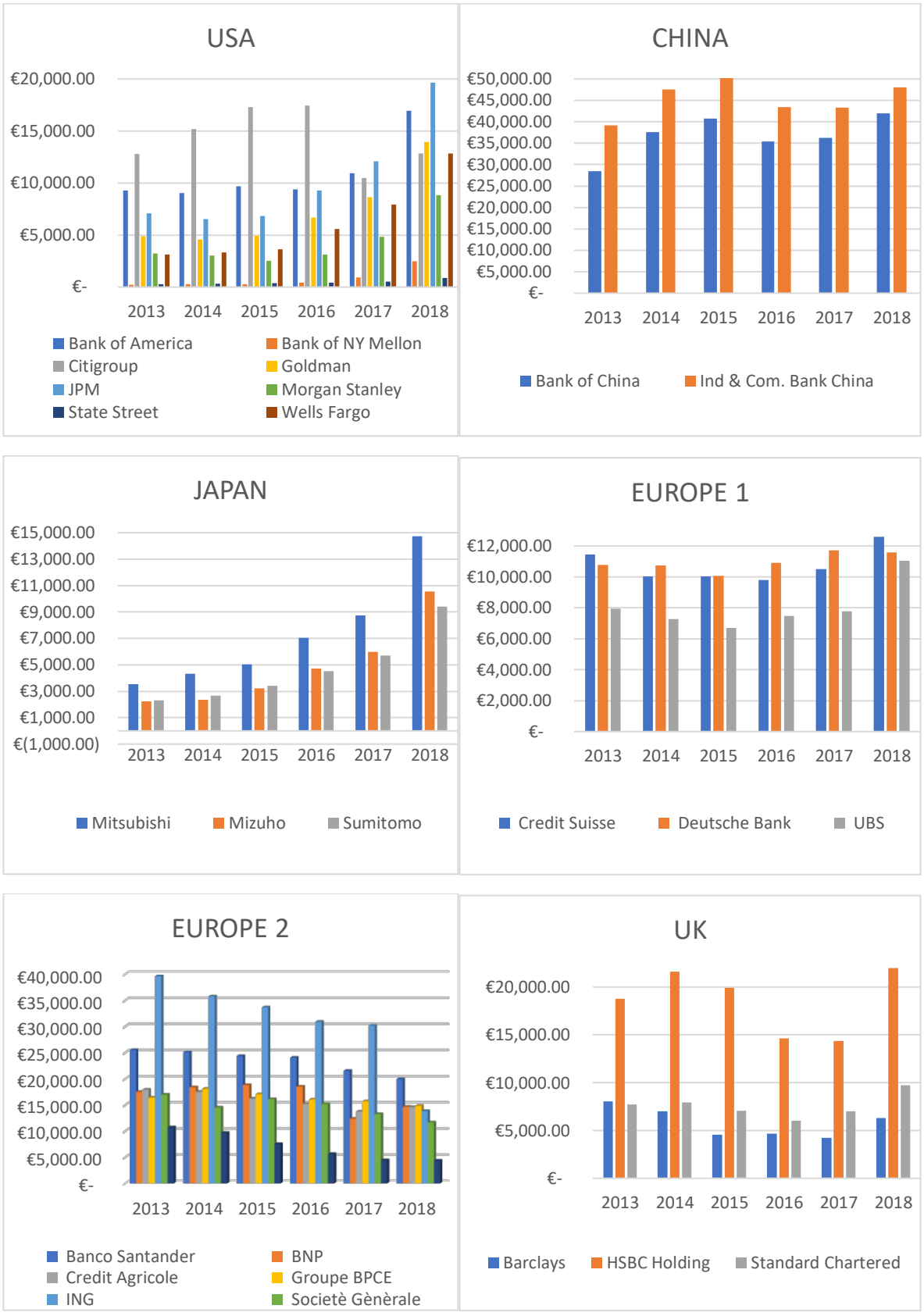
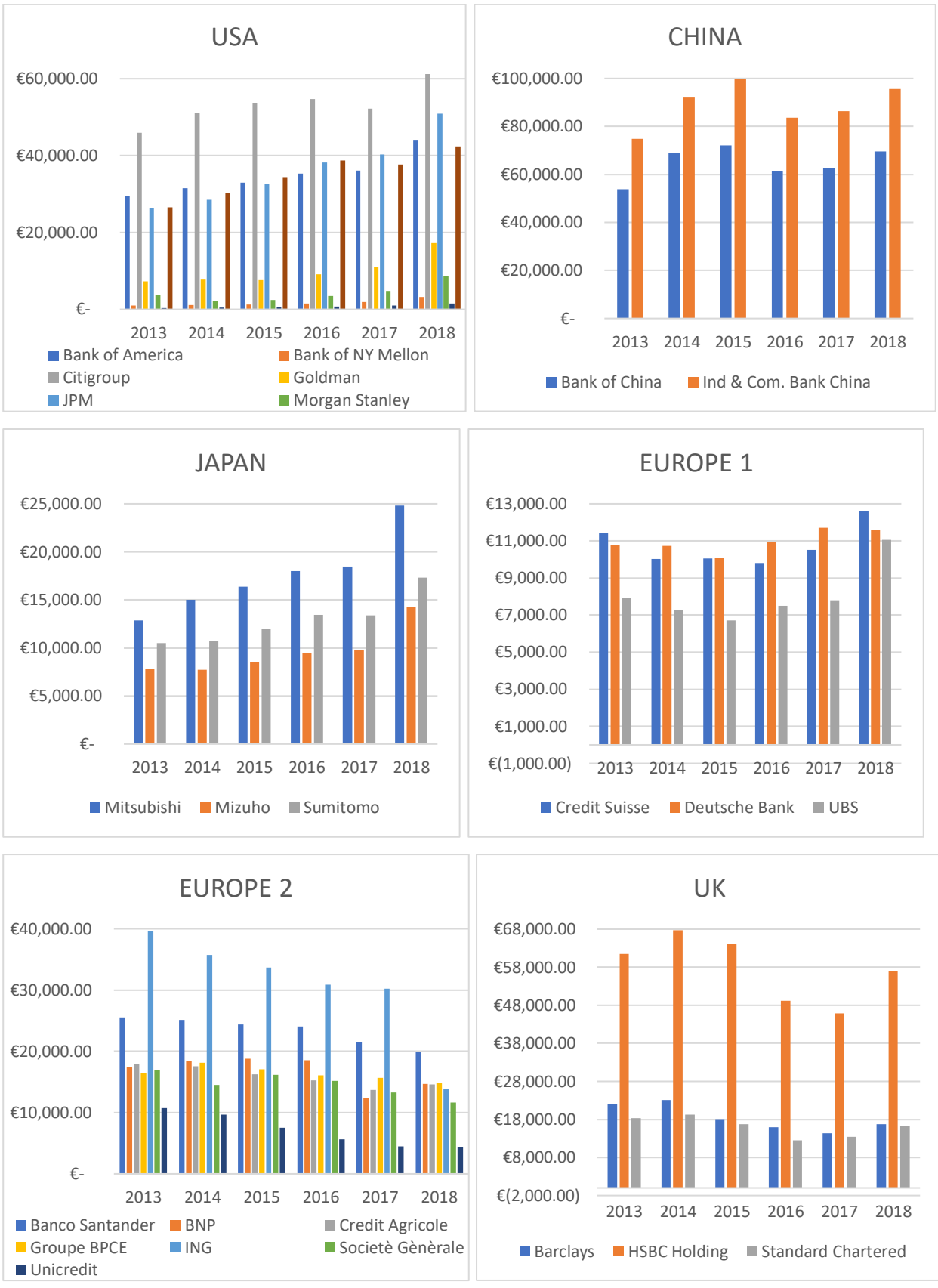


Figure 9: Interest income according to geographical area (2013-2018)



Source: own elaboration

Table 9: *Total Capital Ratio* per area and *minimum external TLAC on RWA requisite* (2013-2018)

								2019	2022
		2013	**2014**	**2015**	**2016**	**2017**	**2018**	**∝RWA**	
CHINA	Bank of China	12,46%	13,87%	14,06%	14,28%	14,19%	14,97%	16%	18%
	Ind & Com. Bank China	13,12%	14,53%	15,22%	14,61%	15,14%	15,39%		
		2013	**2014**	**2015**	**2016**	**2017**	**2018**		
EU1	Credit Suisse	20,60%	20,80%	21,30%	20,50%	20,80%	17,70%	16%	18%
	Deutsche Bank	18,50%	17,20%	16,20%	17,40%	18,60%	17,50%		
	UBS	22,20%	25,50%	26,80%	24,70%	21,70%	19,80%		
		2013	**2014**	**2015**	**2016**	**2017**	**2018**		
EU2	Banco Santander	14,59%	12,03%	14,40%	14,68%	14,99%	14,98%	16%	18%
	BNP	12,50%	12,60%	13,60%	14,50%	14,80%	15,00%		
	Credit Agricole	15,80%	19,60%	20,30%	20,10%	18,30%	17,80%		
	Groupe BPCE	14,40%	15,40%	16,80%	18,50%	19,20%	19,60%		
	ING	16,50%	14,58%	16,92%	19,33%	18,53%	18,40%		
	Société Générale	13,40%	14,30%	16,30%	17,90%	17,00%	16,70%		
	UniCredit	13,61%	13,55%	14,23%	11,66%	18,10%	15,80%		
		2013	**2014**	**2015**	**2016**	**2017**	**2018**		
JPN	Mitsubishi	16,68%	15,53%	15,68%	16,01%	15,85%	16,56%	16%	18%
	Mizuho	14,19%	14,36%	14,58%	15,41%	16,28%	18,24%		
	Sumitomo	14,71%	15,51%	16,58%	17,02%	16,93%	19,36%		
		2013	**2014**	**2015**	**2016**	**2017**	**2018**		
UK	Barclays	15,00%	16,50%	18,60%	19,60%	21,50%	20,70%	16%	18%
	HSBC Holding	14,90%	15,60%	17,20%	20,10%	20,90%	20,00%		
	Standard Chartered	17,00%	16,70%	19,50%	21,30%	21,00%	21,60%		
		2013	**2014**	**2015**	**2016**	**2017**	**2018**		
USA	Bank of America	15,44%	14,60%	15,70%	16,30%	15,90%	15,40%	18%	
	Bank of NY Mellon	17,00%	12,50%	12,50%	13,00%	15,10%	15,10%		
	Citigroup	15,01%	16,32%	18,54%	19,08%	17,31%	16,64%		
	Goldman	19,90%	16,00%	19,10%	17,80%	16,80%	18,00%		
	JPM	14,30%	15,00%	16,00%	15,50%	15,90%	15,50%		
	Morgan Stanley	16,90%	16,40%	20,70%	22,00%	22,90%	21,80%		
	State Street	19,70%	16,60%	17,40%	16,00%	16,50%	16,00%		
	Wells Fargo	15,43%	15,53%	15,77%	16,08%	17,46%	16,60%		

Source: own elaboration

To assess whether institutions have a capital endowment capable of satisfying the minimum external TLAC component proportional to the risk-weighted assets (Table 9), Total Capital Ratio (TCR) was used as a comparison metric, due to the similarities in the structure between the two indicators[3]. The table shows the historical data relating to the TCR and the ΔRWA coefficient applicable between 2019 and 2022. Three G-SIBs located in the Europe 2 area, at the end of 2018, do not meet the minimum requirement for the following year; the remaining ones instead show TCR values already in line with the ΔRWA coefficient to be observed in 2022. In China (the totality of the sub-sample) and in the United States (7 banks out of 8) they do not respect the minimum coefficient: in this regard, it is emphasized that in the USA a requirement of 18% has been adopted since 2019. In Japan, two-thirds of the sample have a TCR level close to 18%. Institutions in the Europe 1 and UK sample amply meet the requirements for 2019: in particular, the British G-SIBs achieve a TCR measurement of over 20%.

Table 10 shows the shortfalls (or percentage gaps) referring to the two years of compliance with the different expected coefficients and calculated considering 2018 as the base year. These observations allow us to measure the percentage of RWA of which a G-SIBs still has to dispone of, in terms of eligible liabilities and/or capital, to manifest a TLAC-compliant condition. The right side of the table shows the amount of the shortfall increased by the additional capital buffer, i.e. the additional amount of capital (expressed only in terms of common equity) requested from the G-SIBs, according to the dimensional bucket to which it belongs.

The values indicated show how the greater capital absorption, deriving from the consideration of the additional buffer, reduces the number of TLAC-compliant institutions, regarding compliance with the 2019 requirement, from 13 to 10: in 2022 the G-SIBs with sufficient capital endowments go from 7 to 4. These results clearly indicate a probable trend on the part of the institutions under analysis in the years to come (and partly already occurred), namely the use of a significant volume of issuance of instruments TLAC-eligible.

[3] The total capital ratio is evaluated considering: CET 1 and additional TIER 1 capital, on the other side, TLAC requirement consists of CET1, additional TIER 1, TIER 2 and senior non preferred bonds.

Numerous placements of TLAC-eligible instruments have already been made since 2017. For the European context only, the following SNPB issues are worth mentioning BNP (11.1.2018) for € 1.250 million; Banco Santander (17.1.2018) for € 1.250 million; UniCredit (18.1.2018) for € 1.500 million; BPCE (11.1.2018) for € 300 million; UniCredit (26.6.2019) for € 750 million; BNP (11.7.2019) for € 1 billion.

Table 10: *RWA minimum external TLAC Shortfall* and *ACB* (2019-2022)

				by 2019	by 2022	by 2019	by 2022	by 2019	by 2022
		2018	**Additional Capital Buffer (ACB%)**	**∝RWA**		**Shortfall %**		**Shortfall % + ACB%**	
CHINA	Bank of China	14,97%	1,50%	16%	18%	1,03%	3,03%	2,53%	4,53%
	Ind. & Com. Bank China	15,39%	1,50%			0,61%	2,61%	2,11%	4,11%
EU1	Credit Suisse	17,70%	1,00%	16%	18%	-1,70%	0,30%	-0,70%	1,30%
	Deutsche Bank	17,50%	1,50%			-1,50%	0,50%	0,00%	2,00%
	UBS	17,50%	1,00%			-1,50%	0,50%	-0,50%	1,50%
EU2	Banco Santander	14,98%	1,00%	16%	18%	1,02%	3,02%	2,02%	4,02%
	BNP	15,00%	1,50%			1,00%	3,00%	2,50%	4,50%
	Credit Agricole	17,80%	1,00%			-1,80%	0,20%	-0,80%	1,20%
	Groupe BPCE	19,60%	1,00%			-3,60%	-1,60%	-2,60%	-0,60%
	ING	18,40%	1,00%			-2,40%	-0,40%	-1,40%	0,60%
	Société Générale	17,00%	1,00%			-1,00%	1,00%	0,00%	2,00%
	UniCredit	15,80%	1,00%			0,20%	2,20%	1,20%	3,20%
JPN	Mitsubishi	15,82%	1,50%	16%	18%	0,18%	2,18%	1,68%	3,68%
	Mizuho	17,89%	1,00%			-1,89%	0,11%	-0,89%	1,11%
	Sumitomo	20,45%	1,00%			-4,45%	-2,45%	-3,45%	-1,45%
UK	Barclays	20,70%	1,50%	16%	18%	-4,70%	-2,70%	-3,20%	-1,20%
	HSBC Holding	20,00%	2,00%			-4,00%	-2,00%	-2,00%	0,00%

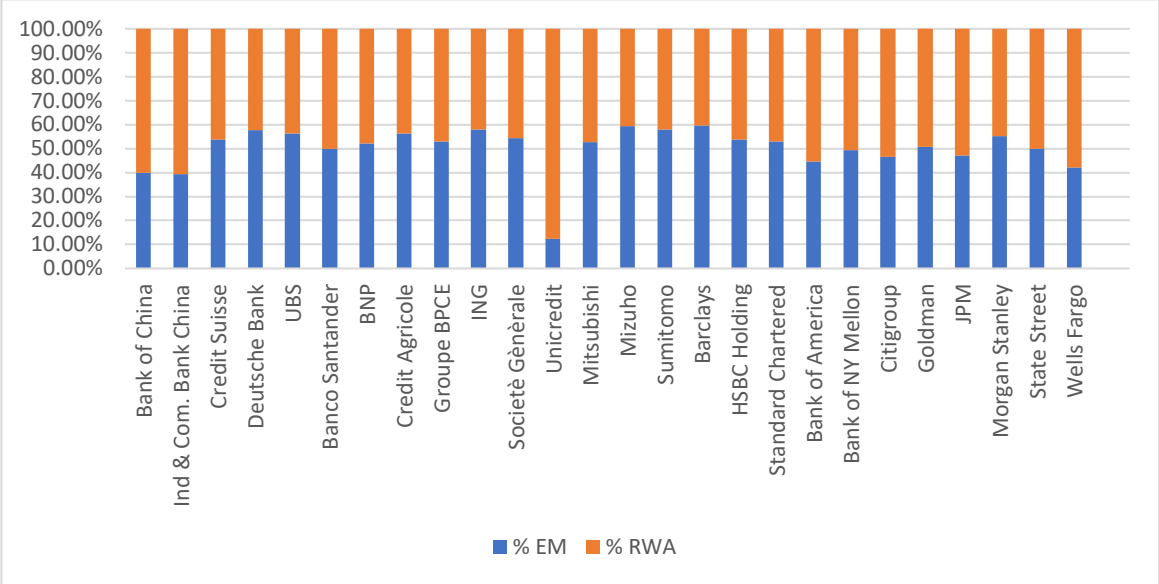
	Standard Chartered	21,60%	1,00%		-5,60%	-3,60%	-4,60%	-2,60%
USA	Bank of America	15,40%	1,50%	18%	2,60%		4,10%	
	Bank of NY Mellon	15,10%	1,00%		2,90%		3,90%	
	Citigroup	16,64%	2,00%		1,36%		3,36%	
	Goldman	17,50%	1,50%		0,50%		2,00%	
	JPM	15,50%	2,50%		2,50%		5,00%	
	Morgan Stanley	21,80%	1,00%		-3,80%		-2,80%	
	State Street	16,00%	1,00%		2,00%		3,00%	
	Wells Fargo	16,60%	1,50%		1,40%		2,90%	

Source: own elaboration

The following table breaks down the TLAC requirement into the EM (a) and RWA (b) components, using the relative regulatory coefficients and considering the temporal succession of the different forecasts (it should be remembered that the United States, since 2019, has adopted the percentages of te full regime, i.e. 18% for RWAs and 7.5% for EM). The total requirement is calculated through the sum of the two components indicated (a + b): a first gap measure is obtained by subtracting the value of the total capital ('c' = TCR * RWA) from the minimum external TLAC requirement (a + b - c). It should be noted that instruments not included in the total capital were not taken into account in the valuations expressed. Since the additional capital buffer ('d' = ACB% * RWA) is known, to obtain the total TLAC gap, it will be sufficient to add this value (a + b - c + d) to the previous result. The results obtained, even if partial and relatively up to date, can be considered as proxies for the issues of eligible instruments that will become necessary for the overall sample considered. In relation to the nature of the requirement, partly related to the riskiness of the assets and partly related to the volumes of activity, it is also interesting to note that 17 out of 26 institutions (in each period considered) have a minimum external TLAC requirement. relative to the higher EM component compared to that calculated on the RWAs: G-SIBs located in the United States (5 out of 8) and in China (the totality) are instead characterized by an opposite condition. The percentage of evidence of the different

determinants of the need connected to the satisfaction of the new requirement is obtained by examining Figure 10.

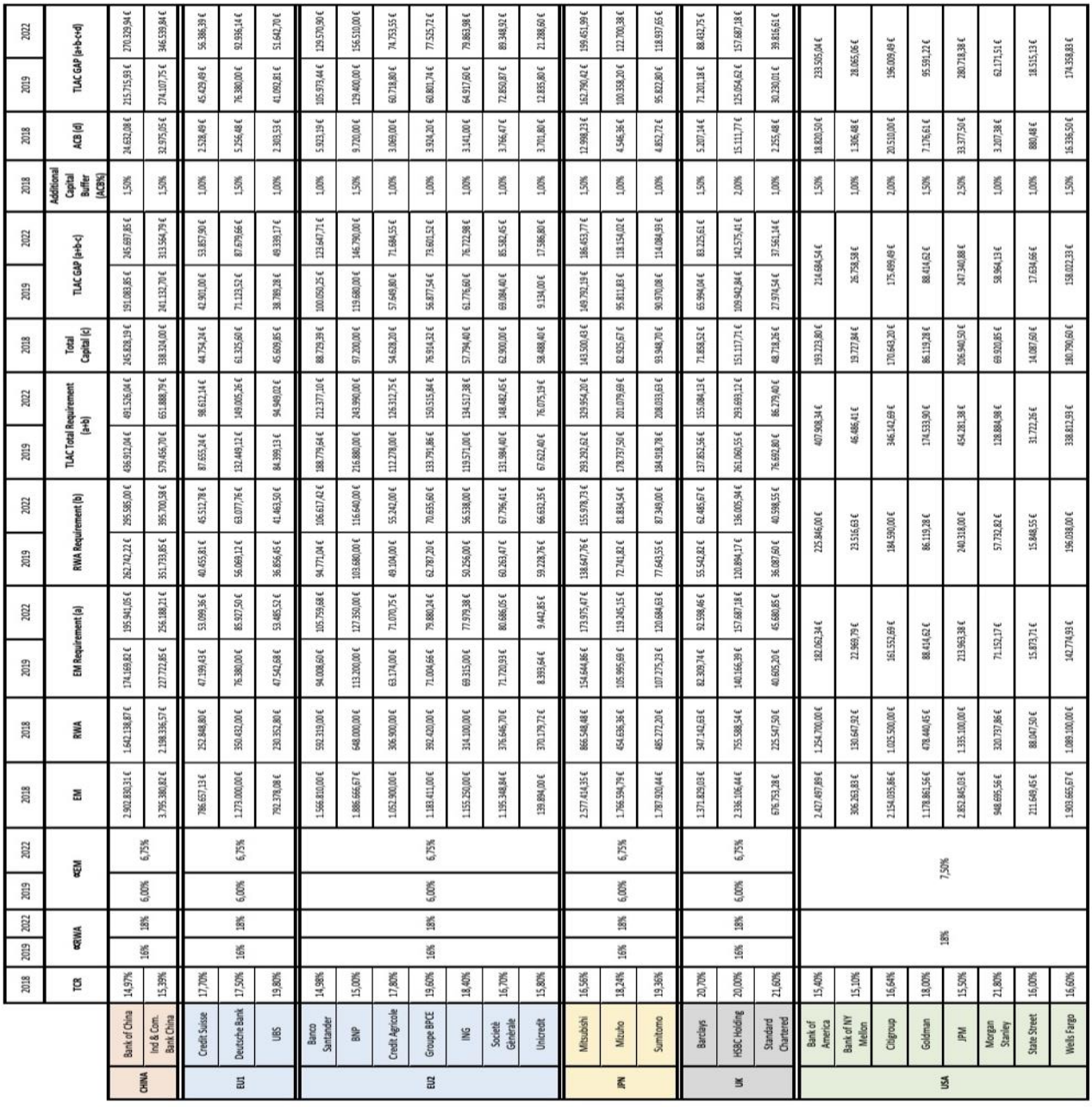
Figure 10: *minimum external TLAC determinants in percentage* (2022)[4]



Source: own elaboration

[4] Unicredit represent an outlier in Figure 10. As stated in their first quarter of 2022 balance sheet the minimum requirement is 21.55% and the total risk exposure is 18% with a combined capital reserve applicable to the group of 3.55%.

Table 11: *TLAC gap* and additional *buffer* (2019-2022)



		TCR		RCBWA			RCBM			EM		RWA		EM Requirement (a)			RWA Requirement (b)			TLAC Total Requirement (a+b)			Total Capital (c)			TLAC GAP (a+b-c)			Additional Capital Buffer (ACB%)			ACB (d)			TLAC GAP (a+b-c+d)		
		2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022	2018	2019	2022
CHINA	Bank of China	14,97%	16%	18%	6,00%		6,75%	2.902.810,31 €		1.642.138,87 €	174.169,82 €		195.941,05 €	262.742,22 €		295.585,00 €	436.912,04 €		491.536,04 €	245.828,19 €		265.697,85 €	191.083,85 €		245.697,85 €	1,50%		1,50%	24.632,08 €		24.632,08 €	215.715,93 €		270.329,94 €			
	Ind & Com. Bank China	15,39%						3.795.380,82 €		2.188.336,57 €	227.722,85 €		256.188,21 €	351.733,85 €		395.700,58 €	579.466,70 €		651.888,79 €	338.324,00 €		313.564,79 €	241.132,70 €		313.564,79 €	1,50%		1,50%	32.975,05 €		32.975,05 €	274.107,75 €		346.539,84 €			
EU1	Credit Suisse	17,70%	16%	18%	6,00%		6,75%	786.657,13 €		252.948,80 €	47.199,43 €		53.099,36 €	45.512,78 €		45.512,78 €	87.655,24 €		98.612,14 €	44.754,24 €		56.386,39 €	42.901,00 €		53.857,90 €	1,00%		1,00%	2.528,40 €		2.528,40 €	45.429,49 €		56.386,39 €			
	Deutsche Bank	17,50%						1.273.000,00 €		350.432,00 €	76.380,00 €		85.927,50 €	63.077,76 €		63.077,76 €	132.449,12 €		149.005,26 €	61.325,60 €		87.679,66 €	71.123,52 €		87.679,66 €	1,50%		1,50%	5.256,48 €		5.256,48 €	76.380,00 €		92.936,14 €			
	UBS	19,80%						792.378,08 €		230.352,80 €	47.542,68 €		53.485,52 €	36.856,45 €		41.463,50 €	84.399,13 €		94.949,02 €	45.609,85 €		49.339,17 €	38.789,28 €		49.339,17 €	1,00%		1,00%	2.303,53 €		2.303,53 €	41.092,81 €		51.642,70 €			
EU2	Banco Santander	14,98%	16%	18%	6,00%		6,75%	1.566.810,00 €		592.319,00 €	94.008,60 €		105.759,68 €	106.617,42 €		106.617,42 €	188.779,64 €		212.377,10 €	88.739,39 €		123.647,71 €	100.050,25 €		123.647,71 €	1,00%		1,00%	5.923,19 €		5.923,19 €	105.973,44 €		129.570,90 €			
	BNP	15,00%						1.886.666,67 €		648.000,00 €	113.200,00 €		127.350,00 €	103.680,00 €		116.640,00 €	216.880,00 €		243.990,00 €	97.200,00 €		146.790,00 €	119.680,00 €		146.790,00 €	1,50%		1,50%	9.720,00 €		9.720,00 €	129.400,00 €		156.510,00 €			
	Credit Agricole	17,80%						1.652.900,00 €		306.900,00 €	63.174,00 €		71.070,75 €	49.104,00 €		55.242,00 €	112.278,00 €		126.312,75 €	54.628,20 €		71.684,55 €	57.648,00 €		71.684,55 €	1,00%		1,00%	3.069,00 €		3.069,00 €	60.718,80 €		74.753,55 €			
	Groupe BPCE	19,60%						1.183.411,00 €		392.400,00 €	71.004,66 €		79.880,24 €	62.787,20 €		70.635,60 €	133.791,86 €		150.515,84 €	76.914,32 €		93.877,54 €	56.877,54 €		73.601,52 €	1,00%		1,00%	3.934,20 €		3.934,20 €	60.801,74 €		77.525,72 €			
	ING	18,40%						1.155.250,00 €		314.100,00 €	69.315,00 €		77.979,38 €	50.256,00 €		56.538,00 €	119.571,00 €		134.517,38 €	57.794,40 €		76.722,98 €	61.776,60 €		76.722,98 €	1,00%		1,00%	3.141,00 €		3.141,00 €	64.917,60 €		79.863,98 €			
	Société Générale	16,70%						1.195.348,84 €		376.646,70 €	71.720,93 €		80.686,05 €	60.263,47 €		67.796,41 €	131.984,40 €		148.482,45 €	62.900,00 €		85.582,45 €	69.084,40 €		85.582,45 €	1,00%		1,00%	3.766,47 €		3.766,47 €	72.850,87 €		89.348,92 €			
	Unicredit	15,80%						139.894,00 €		370.179,72 €	8.393,64 €		9.442,85 €	59.228,76 €		66.632,35 €	67.622,40 €		76.075,19 €	58.488,40 €		17.586,80 €	9.134,00 €		17.586,80 €	1,00%		1,00%	3.701,80 €		3.701,80 €	12.835,80 €		21.288,60 €			
JPN	Mitsubishi	16,56%	16%	18%	6,00%		6,75%	2.577.414,35 €		865.548,48 €	154.644,86 €		173.975,47 €	138.647,76 €		155.978,73 €	293.292,62 €		329.954,20 €	143.500,48 €		186.453,77 €	149.792,19 €		186.453,77 €	1,50%		1,50%	12.988,32 €		12.988,32 €	162.790,42 €		199.451,99 €			
	Mitsuho	18,24%						1.765.594,79 €		454.636,36 €	105.995,69 €		119.245,15 €	72.741,82 €		81.834,54 €	178.737,50 €		201.079,69 €	82.925,67 €		118.154,02 €	95.811,83 €		118.154,02 €	1,00%		1,00%	4.546,36 €		4.546,36 €	100.358,20 €		122.700,38 €			
	Sumitomo	19,36%						1.787.920,44 €		485.272,20 €	107.275,23 €		120.684,63 €	77.643,55 €		87.349,00 €	184.918,78 €		208.033,63 €	93.948,70 €		114.084,33 €	90.970,08 €		114.084,33 €	1,00%		1,00%	4.852,72 €		4.852,72 €	95.822,80 €		118.937,05 €			
UK	Barclays	20,70%	16%	18%	6,00%		6,75%	1.371.829,03 €		347.142,63 €	82.309,74 €		92.598,46 €	55.542,82 €		62.485,67 €	137.852,56 €		155.084,13 €	71.858,52 €		83.225,61 €	65.994,04 €		83.225,61 €	1,50%		1,50%	5.207,14 €		5.207,14 €	71.201,18 €		88.432,75 €			
	HSBC Holding	20,00%						2.336.106,44 €		755.588,94 €	140.166,39 €		157.687,18 €	120.894,17 €		136.005,94 €	261.060,55 €		293.693,12 €	151.117,71 €		142.575,41 €	109.942,84 €		142.575,41 €	2,00%		2,00%	15.111,77 €		15.111,77 €	125.054,62 €		157.687,18 €			
	Standard Chartered	21,60%						676.753,28 €		225.547,59 €	40.605,20 €		45.680,85 €	36.087,60 €		40.598,55 €	76.692,80 €		86.279,40 €	48.718,26 €		37.561,14 €	27.974,54 €		37.561,14 €	1,00%		1,00%	2.255,48 €		2.255,48 €	30.230,01 €		39.816,61 €			
USA	Bank of America	15,40%	18%	18%	7,50%			2.427.497,89 €		1.254.700,00 €	182.062,34 €			225.846,00 €			407.908,34 €			193.723,80 €			214.684,54 €			1,50%			18.820,56 €			233.505,04 €					
	Bank of NY Mellon	15,10%						306.353,83 €		130.647,26 €	22.969,79 €			23.516,63 €			46.486,41 €			19.727,84 €			26.758,58 €			1,00%			1.306,48 €			28.065,06 €					
	Citigroup	16,64%						2.154.055,86 €		1.025.500,00 €	161.552,69 €			184.590,00 €			346.142,69 €			170.643,20 €			175.499,49 €			2,00%			20.510,00 €			196.009,49 €					
	Goldman	18,00%						1.178.861,56 €		478.440,45 €	88.414,62 €			86.119,28 €			174.533,90 €			86.119,28 €			88.414,62 €			1,50%			7.176,61 €			95.591,22 €					
	JPM	15,50%						2.852.845,03 €		1.335.100,00 €	213.963,38 €			240.318,00 €			454.281,38 €			206.940,50 €			247.340,88 €			2,50%			33.377,50 €			280.718,38 €					
	Morgan Stanley	21,80%						948.695,56 €		320.737,86 €	71.152,17 €			57.732,82 €			128.884,98 €			69.920,85 €			58.964,13 €			1,00%			3.207,38 €			62.171,51 €					
	State Street	16,00%						211.640,45 €		88.047,50 €	15.873,71 €			15.848,55 €			31.722,26 €			14.087,60 €			17.634,66 €			1,00%			880,48 €			18.515,13 €					
	Wells Fargo	16,60%						1.903.665,67 €		1.089.100,00 €	142.774,93 €			196.038,00 €			338.812,93 €			180.790,60 €			158.022,33 €			1,50%			16.336,50 €			174.358,83 €					

Source: own elaboration

Using the gaps obtained (referring to 2022 and inclusive of the additional capital buffer), we finally propose a breakdown of the TLAC gaps divided by geographical area: due to the composition of the sample, the greatest needs are found in the United States, Europe, and China.

Table 12: *TLAC gap* per geographical area (2022)

		Absolute		Percentage	
		2022		2022	
		TLAC gap	Sum per geographical area	*TLAC gap*	Sum per geographical area
CHINA	Bank of China	270.329,94 €	616.869,78 €	43,8%	18,9%
	Ind & Com. Bank China	346.539,84 €		56,2%	
EU1	Credit Suisse	56.386,39 €	200.965,23 €	28,1%	6,2%
	Deutsche Bank	92.936,14 €		46,2%	
	UBS	51.642,70 €		25,7%	
EU2	Banco Santander	129.570,90 €	628.861,66 €	20,6%	19,3%
	BNP	156.510,00 €		24,9%	
	Credit Agricole	74.753,55 €		11,9%	
	Groupe BPCE	77.525,72 €		12,3%	
	ING	79.863,98 €		12,7%	
	Societè Gènèrale	89.348,92 €		14,2%	
	UniCredit	21.288,60 €		3,4%	
JPN	Mitsubishi	199.451,99 €	441.090,03 €	45,2%	13,5%
	Mizuho	122.700,38 €		27,8%	
	Sumitomo	118.937,65 €		27,0%	
UK	Barclays	88.432,75 €	285.936,54 €	30,9%	8,8%
	HSBC Holding	157.687,18 €		55,1%	
	Standard Chartered	39.816,61 €		13,9%	
USA	Bank of America	233.505,04 €	1.088.934,65 €	21,4%	33,4%
	Bank of NY Mellon	28.065,06 €		2,6%	
	Citigroup	196.009,49 €		18,0%	
	Goldman	95.591,22 €		8,8%	

	JPM	280.718,38 €		25,8%	
	Morgan Stanley	62.171,51 €		5,7%	
	State Street	18.515,13 €		1,7%	
	Wells Fargo	174.358,83 €		16,0%	
	TOTALE		**3.262.657,89 €**		**100,0%**

Source: own elaboration

6. Conclusions

The proposed analysis, after a presentation of the characteristics of the new regulatory requirement envisaged for the G-SIBs, focuses on a series of macro and microeconomic effects connected to the introduction of the TLAC and then proceeds to some checks of empirical character concerning a sample of 26 institutes, distributed in 5 distinct geographical areas.

The data processed show how the introduction of measures aimed at reinforcing the sources to be used in the event of failure of systemically important banks increases the need for funds to be used in this regard, with a possible increase in the cost of funding and probable repercussions on the pricing of loans: this should lead to a more conscious assumption of risks and, in general, to a more strict observance of the principles of sound and prudent management, especially in terms of the development of business volumes. The provision of internal resolution mechanisms for banking crises (so-called bail-in) inevitably leads to the adoption of rules that induce a significant reinforcement of the sources to be used to avoid liquidation risks of institutions whose default, due to its characteristics, it could undermine the stability of the international financial system.

Simultaneous compliance with the prudential supervisory rules referable to the Basel 3 framework and with the new provisions relating to the ability to absorb losses by G-SIBs seems to outline a safety net within which larger intermediaries can act in conditions of balanced management, aimed at balancing the risk and return profiles deriving from the business model adopted.

Furthermore, it is believed that, although the repercussions resulting from the introduction of the TLAC in terms of impacts at the level of each individual institution, as

well as with respect to the real economy, are not negligible, the benefits that can be achieved in terms of resilience of the main market players and the lower costs for the community, deriving from generalized crises in the banking sector, are far greater.

In light of this conclusion, policymakers may want to consider the trade-offs between short-term costs and long-term benefits when implementing the TLAC and to take measures to mitigate any adverse impacts on the economy and individual institutions. Ultimately, the policy implication is that the TLAC should be viewed as a necessary step towards a safer and more stable financial system, even if it requires some adjustments in the short term.

7. Appendix

Appendix 1: G-SIBs' Interest Expenses - annual percentual variations

		2013	2014	2015	2016	2017	2018
CHINA	Bank of China	-	31,73%	8,67%	-13,27%	2,58%	15,62%
	Ind & Com. Bank China	-	21,22%	9,10%	-16,11%	-0,29%	10,76%
		2013	2014	2015	2016	2017	2018
EU1	Credit Suisse	-	-12,36%	0,15%	-2,29%	7,01%	20,04%
	Deutsche Bank	-	-0,35%	-6,00%	8,37%	7,18%	-0,97%
	UBS	-	-8,48%	-7,72%	11,73%	4,01%	41,82%
		2013	2014	2015	2016	2017	2018
EU2	Banco Santander	-	-1,58%	-2,88%	-1,31%	-10,47%	-7,25%
	BNP	-	4,98%	2,39%	-1,65%	-33,17%	18,47%
	Credit Agricole	-	-2,35%	-7,21%	-6,27%	-9,87%	6,26%
	Groupe BPCE	-	10,26%	-5,78%	-5,88%	-2,14%	-5,53%
	ING	-	-9,71%	-5,90%	-8,17%	-2,26%	-54,17%
	Societè Gènèrale	-	-14,49%	10,95%	-5,78%	-12,70%	-12,09%
	UniCredit	-	-9,78%	-21,96%	-25,10%	-21,14%	-2,13%
		2013	2014	2015	2016	2017	2018
JPN	Mitsubishi	-	22,04%	16,47%	39,94%	24,20%	68,89%

	Mizuho	-	5,54%	38,10%	45,26%	27,35%	76,06%
	Sumitomo	-	15,88%	27,79%	32,01%	26,52%	65,51%
		2013	2014	2015	2016	2017	2018
UK	Barclays	-	-12,80%	-35,26%	2,10%	-8,71%	48,59%
	HSBC Holding	-	15,06%	-7,76%	-26,68%	-1,78%	53,15%
	Standard Chartered	-	2,98%	-10,99%	-14,54%	15,77%	39,08%
		2013	2014	2015	2016	2017	2018
USA	Bank of America	-	-2,94%	7,10%	-2,90%	16,44%	55,01%
	Bank of NY Mellon	-	16,85%	-5,92%	49,79%	120,77%	171,88%
	Citigroup	-	18,86%	13,67%	1,14%	-39,97%	22,63%
	Goldman	-	-5,64%	7,63%	35,58%	28,74%	61,78%
	JPM	-	-7,60%	4,91%	35,28%	30,61%	62,30%
	Morgan Stanley	-	-6,02%	-17,24%	24,43%	54,24%	83,25%
	State Street	-	7,99%	13,27%	10,03%	26,77%	69,83%
	Wells Fargo	-	6,25%	9,66%	52,82%	42,17%	62,17%

Appendix 2: G-SIBs' Interest Expenses - annual percentual variations

		2013	2014	2015	2016	2017	2018
CHINA	Bank of China	-	28,01%	4,76%	-14,80%	1,91%	10,97%
	Ind & Com. Bank China	-	22,96%	8,44%	-16,31%	3,38%	10,72%
		2013	2014	2015	2016	2017	2018
EU1	Credit Suisse	-	-1,58%	-2,88%	-1,31%	-10,47%	-7,25%
	Deutsche Bank	-	4,98%	2,39%	-1,65%	-33,17%	18,47%
	UBS	-	-2,35%	-7,21%	-6,27%	-9,87%	6,26%
		2013	2014	2015	2016	2017	2018
EU2	Banco Santander	-	-1,58%	-2,88%	-1,31%	-10,47%	-7,25%
	BNP	-	4,98%	2,39%	-1,65%	-33,17%	18,47%
	Credit Agricole	-	-2,35%	-7,21%	-6,27%	-9,87%	6,26%

	Groupe BPCE	-	10,26%	-5,78%	-5,88%	-2,14%	-5,53%
	ING	-	-9,71%	-5,90%	-8,17%	-2,26%	-54,17%
	Societè Gènèrale	-	-14,49%	10,95%	-5,78%	-12,70%	-12,09%
	UniCredit	-	-9,78%	-21,96%	-25,10%	-21,14%	-2,13%
		2013	2014	2015	2016	2017	2018
JPN	Mitsubishi	-	16,66%	9,03%	9,84%	2,68%	34,24%
	Mizuho	-	-1,77%	11,06%	10,76%	3,74%	45,17%
	Sumitomo	-	2,34%	11,65%	12,15%	-0,35%	29,17%
		2013	2014	2015	2016	2017	2018
UK	Barclays	-	5,07%	-21,94%	-11,19%	-9,91%	15,95%
	HSBC Holding	-	10,32%	-5,30%	-23,34%	-6,68%	24,25%
	Standard Chartered	-	4,91%	-13,41%	-24,72%	6,97%	20,79%
		2013	2014	2015	2016	2017	2018
USA	Bank of America	-	6,46%	4,57%	7,22%	2,22%	21,96%
	Bank of NY Mellon	-	21,87%	6,68%	26,96%	22,53%	69,28%
	Citigroup	-	10,91%	5,37%	1,84%	-4,61%	19,06%
	Goldman	-	8,09%	-2,31%	17,90%	21,55%	55,34%
	JPM	-	7,90%	13,99%	17,30%	5,62%	26,46%
	Morgan Stanley	-	-41,51%	11,26%	42,71%	35,21%	79,24%
	State Street	-	35,02%	29,37%	23,50%	47,82%	57,56%
	Wells Fargo	-	14,13%	13,99%	12,55%	-2,73%	12,37%

8. Bibliography

Bank for International Settlements, (2015), *Assessing the economic costs and benefits of TLAC implementation*, Basel.

Bank of Italy, (2021), *TLAC-Eligible Debt: Who Holds It? A View from the Euro Area*, Bank of Italy Occasional Paper No. 604.

Basel Committee on Banking Supervision, (2015), *TLAC Quantitative impact study report*., B.I.S., Basel.

Basel Committee on Banking Supervision, (2017), *TLAC - executive summary*, B.I.S., Basel.

Basel Committee on Banking Supervision, (2018), *Global systemically important banks: revised assessment methodology and the higher loss absorbency requirement*, B.I.S., Basel.

Brierley P. G., (2017), *Ending too-big-to-fail: progress since the crisis, the importance of loss-absorbing capacity and the UK approach to resolution*, European Business Organization Law Review, n. 18.

Clerc L., (2015), *Higher capital requirements for G-SIB: systemic risk vs. lending to the real economy*, European Economy. Banks, Regulation and the Real Sector, Rome.

Colucci M., (2018), *Bond senior non preferred: cosa sono e quali prospettive*, Atlante, Prometeia.

Directive 2014/59/UE, *BRRD - Bank Recovery and Resolution Directive*.

Directive 2017/2399/UE, *BRRD - Bank Recovery and Resolution Directive*.

Fernàndez. S. L., Pardo J. C., Santillana V., Garcia J., (2015), *EU loss-absorbing capacity requirement: final MREL guidelines*, BBVA Research.

Financial Stability Board, (2010), *Reducing the moral hazard posed by systemically important financial institutions; FSB recommendations and timelines,* Basel.

Financial Stability Board, (2011 a), *Key attributes of effective resolutions regimes for financial institutions*, Basel.

Financial Stability Board, (2011 b), *Policy measures to address systemically important financial institutions,* Basel.

Financial Stability Board, (2013), *Progress and next steps towards ending "too-big-to-fail" (TBTF) - report of the financial stability board to the G-20*, London.

Financial Stability Board, (2014), *Adequacy of loss-absorbing capacity of global systemically important banks in resolution.* Consultative Document, Basel.

Financial Stability Board, (2015 c), *FSB issues final total loss-absorbing capacity standard for global systemically important banks. Press release*, Basel.

Financial Stability Board, (2015 d), *Principles on loss-absorbing and recapitalization capacity of g-sib in resolution - total loss-absorbing capacity (TLAC) term sheet*, Basel.

Financial Stability Board, (2018), *2018 list of global systemically important banks (G-SIB)*, Basel.

Financial Stability Board, (2019 e), *2019 list of global systemically important banks (G-SIB)*, Basel.

Financial Stability Board (2019 f), *Review of the technical implementation of the total loss absorbing capacity (TLAC) standard*, Basel.

Gianmattei A., Iannotta G., Invernizzi D., Resti A., Strizzi M., (2010), *Bank capital under Basel 3: open issues and foreseeable effects*, Baffi Carefin Centre Research, Working Paper n. 21, Milan.

Goodhart C., (2015), *TLAC resolution – and then what?,* Financial Markets Group, London School of Economics.

Gortsos C. V., (2019), *The Single Resolution Mechanism and the Single Resolution Fund: legal aspects of the second main pillar of the Banking Union*, Financial Risk and Stability.

Hasenclever C., (2020), *Total loss-absorbing capacity and minimum requirement for own funds and eligible liabilities: Impact of bail-in rules on balance sheet management and funding*, Journal of Risk Management in Financial Institutions, 13:1, pp. 81-96.

International Monetary Fund, (2017), *Global financial stability report. is growth at risk?*, Washington.

Invernizzi I., (2018), *I senior non preferred bonds: uno strumento innovativo – parte prima*, Risk & Compliance.

Jiangping Z., Rutledge V., Bossu W., Dobler M., Jassaud N., Moore M. , (2013), *Resolving systemically important financial institutions: mandatory recapitalization of financial institutions using "bail-ins*", in Enoch C., Everaert L., Tressel T., Zhou J., *From fragmentation to financial integration in Europe*, International Monetary Fund, Washington.

Kandrac J., Schlusche B., (2017), *Quantitative easing and bank risk taking: evidence from lending*, Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System, Washington.

Kupiec P. H., (2016), *Will TLAC regulations fix the G-SIB too-big-to-fail problem?,* Journal of Financial Stability, n. 24.

Masera R., (2009), *The Great Financial Crisis*, Bancaria Editrice, Rome.

Pwc, (2014), *Ten key points from the FSB's TLAC ratio*, London.

Sironi A., (2018), *The evolution of banking regulation since the financial crisis: a critical assessment*, Baffi Carefin Centre Research, Working Paper n. 103.

Speyer B., (2015), *TLAC: systemic risk issues and the impact on strategies of cross-border banks,* Bezpieczny Bank, n. 3(60), Warsaw.

Trigo T., (2019), *Understanding Tier 3 Issued by Banks*, BNP Paribas.

Tröger T. H., (2019), *Why MREL won't help much*, Journal of Banking Regulation, n. 20.

Yap B., (2017), *Deal: world's first senior non-preferred samurai bond*, International Financial Law Review.

ESG default risk mitigation effect: a time-sectorial analysis.

E. Palmieri [♠], M. Polato [♠]

*Department of Economics and Statistics, University of Udine, Udine, Italy

Corresponding author: Egidio Palmieri Department of Economics and Statistics, University of Udine, Italy, Address: Udine, Via Tomadini 30/A, Phone: +39 342 0556986,

email: palmieri.egidio@spes.uniud.it

Abstract

In the last decade, environmental, social, and governance (ESG) factors have become a theme of interest for banks, researchers, and policymakers. Given this broad attentiveness to the topic, researchers have studied the benefits of introducing ESG score on creditworthiness assessment procedures utilizing models based on market values and balance sheet items. Nonetheless, their findings are characterized by a lack of uniformity in the implication of ESG scores.

Our study is based on 335 European listed companies from 2010 to 2020. In order to explore the impact of ESG score on firms' default likelihood, we developed a set of difference-in-difference economic regressions for each probability of default described in the table above. The objectives of the present study are resumed in the following research questions: (i) RQ1: To what extent do ESG individual pillars contribute to reducing firms' default probabilities?; (ii) RQ2: How ESG risk mitigation effect is amplified or reduced by the sector firms belong to?

In this paper, we have empirically replied to RQ1: environmental improvements produce a more significant risk diversification effect than government and social score ones. Conversely, a higher social score will consistently affect medium-long term default probabilities. Generally, ESG and environmental regression coefficients follow a u-shaped

♠ University of Udine. Department of Economics and Statistics. Via Tomadini 30A – 33100 Udine. Email: palmieri.egidio@spes.uniud.it.

progression as the time horizon expands. A further contribution is linked to difference-in-difference results: short-medium term default probabilities are sensible to improvements in ESG scores.

Our overall results reveal that default probabilities are influenced by the sector firms belong to. Each sector we consider is responsible for an increase in the default likelihood; more specifically, the energetic sector experiences the most significant impact due to the intrinsic exposition to sustainability issues. On the other hand, industrial and material sectors present a less consistent contribution to the probability of default. However, for each sector, the magnitude of the coefficient increases as the time horizon expands.

1. *Introduction*

The integration of environmental, social and governance (ESG) issues into risk taking policies and firms' strategic planning has become topic of interest for banks, managers, researchers, and policy makers. The entire financial industry focused the attention on sustainability matters and more than $30 trillion of asset under management are invested according to environmental-friendly criteria (Christensen et al., 2021). The greatest awareness developed around this thematic is given due to the Paris Climate Agreement held in December 2015 and the release by the United Nations of the Agenda for Sustainable Development, which define 17 objectives on social and environmental issues that all the 190 member states have committed to pursue by 2030 (United Nations, 2015a; United Nations, 2015b). In 2018, the European Commission admitted this instance publishing the "Action Plan: Financing Sustainable Growth", a document with the purpose of speeding up the development of a more sustainable European financial system.

Researchers, given this wide interest on the topic, have studied the benefits connected the introduction of ESG score on credit worthiness assessment procedures exploiting market values, balance sheet items and the ESG reports that specialized rating agencies are publishing for an ever-growing number of companies (Stubbs, 2016; Berg et al., 2019; Gibson, 2021; Barth et al., 2021). A default risk mitigation effect has been discovered for

firms that implement environmental, social and governance policies (Devalle et al., 2017; Chiaramonte et al., 2021). Despite this evidence, there are currently problems regarded to rating uniformity and transparency among rating agencies all over the world (Stubbs, 2016). This "*rating divergence*" constitutes a deterrent for a systematic adoption of ESG metrics in the assessment of creditworthiness (Berg et al., 2019; Christensen et al., 2021).

Banks are interested in including these metrics into their risk-taking procedures because ESG lending provides a source of diversification, and the implementation of sustainable procedures, as suggested into EBA guidelines on loan originating and monitoring, should be integrated with risk appetite framework and strategic planning (Kim, 2021; EBA, 2020a; EBA, 2020b). Furthermore, banks should identify ESG risks at the level of key sectors, geographical areas, and products provided to offer a range of services resilient to these risks, reminding that this new class of risks were not previously considered (Rocca, 2021).

Jointly to the introduction of IFRS 9, banks are required to assess the lifetime probability of default, when a credit position deteriorate at least to stage two, note as underperforming stage. In this optic, the inclusion of ESG scoring will provide a tool for banks to correctly assess the probability of default with time horizons greater than one year (Gubareva, 2021).

Firms', that take care about sustainability issues can contribute to a durable development and at the same time benefit from a reduction of the cost of capital charged by banks and financial markets. In fact, the decrease of the cost of capital is a consequence of an improved credit worthiness (Bhattacharya and Sharma, 2019).

In order to enlarge the knowledge matured in the previous literature, we developed two research questions at which we provide response: (1) *Does ESG score variation has a major impact on firms' probability of default on longer time horizons?* (2) Does the *impact of ESG score on probability of default changes in function of the sector to which firms belong?*. The former research question is a topic of interest for banks and regulators. In fact, credit institution in appliance to the EBA guidelines mentioned and IFRS 9, are interested in evaluating the impact of ESG score variation on default probability for different time frames. At the same

time, regulators are interested at the effect in terms of capital allocation consequently to the firms' risk mitigation effect on time spans greater than one year. The second research question will interest banks due to the relevance in terms of risk diversification strategies. Banks that integrate ESG score in their risk appetite framework can dynamically adjust their capital allocation in function of macroeconomic variables, sectorial and geographical areas.

With the objective to provide reply to the mentioned research question we structured the present paper as follow: (i) section 2, it is provided a review of the literature concerning environmental, social and governance issues, the relationship among ESG and firms' riskiness, and the theoretical model applied for the development of the econometric model; (iii) in section 3 it is presented the dataset, a brief description of the variables and the selection criteria. Furthermore, it is explained the econometric model based on a difference-in-difference analysis; (iv) in section 4 the result of the econometric analysis is presented; (v) in section 5 are proposed the final discussion and conclusions.

2. *Literature Review and Theoretical Background*

In literature there is evidence that ESG metrics can increase firms' creditworthiness, in fact, both ESG individual components and ESG overall score are able to reduce companies' probability of default (Devalle et al., 2017; De Santis et al., 2020). These relationships find confirmation in a research based on a sample of 400 European firms, according to which ESG score reduces credit risk of nonfinancial firms (Höck et al., 2020). An additional study, focused on European firms, confirms that ESG leads to a contraction of total and idiosyncratic risk (Sassen et al., 2016). Furthermore, the increase of ESG scoring is correlated to a reduction of downside risk and default risk (Jang et al., 2020). Another study, based on an ordered logistic regression using a sample of 500 Indians listed companies, found that ESG score can increase companies credit worthiness for small and medium sized firm. Given a positive correlation among market capitalization and credit score, it possible to assert that big companies already take advantage from higher credit

scores and ESG produce marginal effects on their probability of default (Bhattacharya and Sharma, 2019).

Another research stream considers CDS spread as a proxy for credit risk. A study, based on a sample of 470 US firms, has validated the ability of ESG metrics to reduce firm risk and the existence of a non-linear U-shape relationship among ESG indicators and CDS spreads (Barth et al., 2021). The authors have found that the risk mitigation effect is more pronounced for firms that improve ESG score starting from a modest level rather than starting from high or very low levels. An empirical work has attested that ESG metrics are correlated with the term structure of credit spread. Thus, countries with a greater attention to ESG issues are characterized by flat credit curves, thus expected lower level of credit risk increases the magnitude of the risk reduction effect related to ESG score (Hübel, 2020).

Multiple studies have found different contributions in reducing firms' probability of default for each ESG component. According to Bhattacharya and Sharma *CSR* performance provide a strong signal of credit worthiness and affect firms' reputation but their conclusions are restricted only to emerging markets (Bhattacharya and Sharma, 2019; Stellner et al., 2015). Agreeing with another study, based on 3.719 Moody's credit rating reports, governance accounts for the major in the process of credit worthiness improvement (Cash, 2018; Kiesel and Lücke, 2019). Other papers emphasize the prevalence of the environmental sphere over social and governance ones (Sassen et al., 2016; Gibson, 2021). In contrast to the latter, a study has observed a positive effect of governance and social dimensions on credit risk, while the environment sphere increases firms' riskiness (Blancard et al., 2016; Kim and Li, 2021).

Although it has been empirically demonstrated the attribution of lower probability of default for companies characterized by high ESG scores, there is a problem inherent the lack of uniformity and transparency of the methods for detecting ESG metrics. In fact, raters issue an ESG rating tailored on customers' needs, and to remain competitive on the market, they are adverse in sharing the know-how acquired (Stubbs, 2016; Avetisyan and Hockerts, 2017). On the other side, uniformity among with transparency grant rating comparison and reduce the necessity for stakeholders to carry out their own research and increase

information efficiency (Ingo, 2020). Regulators should face this trade-off developing a proper legal framework able to increase interest in ESG metrics. In addition, rating agencies do not implement sustainability principles into their assessment processes, so common and recognized framework is needed (Olmedo et al., 2019). The problem of the lack of uniformity regarding ESG indicators has been faced in a paper that observed three different types of divergence: (1) *scope divergence;* (2) *measurement divergence;* (3) *weight divergence* (Berg et al., 2019; Christensen et al., 2021). The author has observed that measurement divergence is the prominent reason why for a specific firm ESG score is assessed differently when considering multiple rating agencies. Furthermore, once the rater assigns to a firm a good score in one category it is inclined to assign, to that firm, positive scores in the other categories evaluated (*rater effect*). The magnitude of measurement divergence has been estimated in a paper built on a sample of American firms belonging to the S&P 500 index. They found that the increase in ESG rating disagreement is positively correlated with stock returns (Gibson, 2021).

An increased attention of national regulation expressed in terms of environment safeguard, social and governance inequality reduction can considerably amplify the effect of ESG score on credit worthiness. Indeed, the risk mitigation effect triggered by ESG score improvement it is more evident in countries with a consolidated and strong attention to environment protection, social and governance issues. In fact, ESG metrics have a greater impact in the reduction of EU firms' probability of default rather than American ones (Barth et al., 2021). A possible explanation is provided by a literature stream according to which, ESG score are more effective in civil law countries rather than common low ones (Liang and Renneboog, 2017; Kim et al., 2021). Civil law countries are stakeholder oriented while common low countries tend to preserve market discretion. On the other side, ESG improvements do not have the same impact on the probability of default. Firms characterized by low credit worthiness may benefit less than firms with higher levels of credit worthiness (Höck et al., 2020). Furthermore, it is observed that in countries characterized by high level of investor protection the cost of capital for firms that take care of ESG issues is lower (Breuer, 2018).

Early literature studied the effect of ESG metrics on credit worthiness considering only a one-year perspective, ignoring long term implication. ESG criteria should represent a managerial incentive to take long term choices (Henisz and McGlinch, 2019). Corporate strategies should consider environment protection, social responsibility, and governance issue due to their impact on credit risk and operational risk (Li et al., 2020). In fact, ESG risk mitigation effect is considerably higher in the long run rather than in other time frames (Hübel, 2020).

ESG criteria can be exploited in rating methods improving the predicting power of credit rating algorithms (Klein, 2019; Michalski and Low, 2020). Another contribution in this sense can be found in an article according to which, the integration of the correlation among credit worthiness and ESG score can help to better estimate firms' actual credit risk (Höck et al., 2020). Other papers raise the lack of predictivity of credit risk using models that incorporate ESG factors (Yang, 2020).

A different literature stream deals with ESG and corporate performance. An empirical study, based on a sample of 4.708 US firms, has observed a positive correlation among ESG score and corporate profitability (Kim and Li, 2021). Consequently, ESG score downgrade can negatively affect firms' market returns and subsequently the investors stock preferences. In this sense, ESG score can alter markets' capital allocation (Latino et al., 2021). Always according to the perspective of an investor, ESG offers and additional protection against small firms' credit risk (Jang et al., 2020). In addition, the lack of consideration of ESG score makes portfolio performance more exposed to market changes (Garcia et al., 2019; Ielasi et al., 2020).

With the objective to analyze with which extent ESG score are able to decrease firms' riskiness we developed a set of hypotheses to be tested. The first set regards the ability of ESG metrics to reduce the probability of default of firms in time frames longer than the annual horizon.

HYP1: The individual pillars of ESG contribute significantly to reducing firms' default probabilities

The logic behind hypothesis 1 is that the effects originated by the implementation of environmental, social and governance dimensions in firms' strategy, produces benefits on the long run (Kim et al., 2021). As investments in reputation, ESG reflect positively on probability of default estimated on periods of time greater than a single year. In the evaluation of credit worthiness, the probability of default considers different time spans, starting from monthly probabilities up to lifetime ones. In this work, we will restrict these probabilities to yearly dimensions with PD starting from one year up to five years.

After the issue of the final version of IFRS 9 by International Accounting Standard Board (IASB), a noticeable attention is assumed by the banking sector for models able to estimate firms' multiperiod default probability (Xu, 2016). According to the author to assess firms' PD, the most relevant component and hardest to evaluate is the expected credit losses lifetime (Duffie et al, 2007; Gubareva, 2021). With objective to reduce the number of estimations, in this work, we will use the probability of default provided by Bloomberg. These probabilities are calculated using the Merton distance to default model.

For the banking sector, the implementation of ESG metrics into loan assessment and on-going evaluation became mandatory following the introduction of *loan origination monitoring guidelines* issued by European Banking Authority (EBA, 2019; EBA, 2020a; EBA, 2020b; EBA, 2020c; EBA, 2021).

HYP2: The ESG risk mitigation effect has a differential impact on default probabilities, depending on the sector in which the firm operates.

Companies in sectors most exposed to environmental problems will benefit most from positive changes in the ESG profile. On the other side, on the market will exist firms that because of their core business, technical impediments or exogenous issues react less to ESG score (Eccles et al., 2012). In this sense, it is possible to identify companies more exposed respectively to environmental, social, governance issues, or any combination of the previous. The analysis of the effects of sectors, evaluated according to Global Industry Classification Standard's (GICS), and ESG score impact on firms' default probabilities has

been analyzed by Aslan et al., (2021). They observe that the greatest risk mitigation effect can be observed for the energy sector.

According to stakeholder theory the interest of the firm in environmental and social issues is rewarded by the market in terms of performance, consequently increasing firm value (Clarkson, 1995; Donaldson and Preston, 1995). In fact, satisfying stakeholders' needs is a way to increase the value of the company (Freeman, 2010). For stakeholder is meant someone with a specific interest in a firm, for example, employees, government, bond holders, stockholders.

Corporate performance should be considered among with risk dimensions, according to the paradigm of risk-return, increases in risk levels are related to higher returns (Fama, 1971; Bettis and Mahajan, 1985; Campbell and Viceira, 2005). This happens because investors pretend higher remuneration for taking riskier positions (Baker and Haslem, 1974). According to the referring literature, the concept of risk is the ideal reduction of performance or company value as result of past strategies or uncertainty regarding future events outcomes (Orlitzky and Benjamin, 2001; Chang et al., 2014). We consider the default risk as measure of risk, and we will study how ESG score affect this configuration of risk. The default risk is the probability with which a debtor will default in a defined time horizon. In accordance with stakeholder theory, an increased attention in social and governance issue will lead to a better consolidation of company relationships with government and financial community, improving firm reputation and brand value (Brown and Dacin, 1997). This concatenation of events makes possible the reduction of firm risk and the diminution of capital constrains (McGuire et al., 1988). Furthermore, the development of social and governance attention constitutes an indicator for excellent management abilities and the availability of high-quality workforce (Turban and Greening 1997; Waddock and Graves 1997; Greening and Turban, 2000). All these factors contribute to the reduction of financial risks and lowers the likelihood of financial distress (Oikonomou et al., 2012).

3. *Data and Methodology*

3.1. Sample and Variable Description

The dataset is made up of annual observations of 111 European companies with a reference time frame that starts in 2010 and ends in 2020. All firms considered are listed in the main European stock indexes and we selected only firms with complete ESG scoring disclosure available starting from 2015 and *Bloomberg* PD calculated over a time horizon of 1, 2, 3, 4 and 5 years. The unavailability of data referring to the Z-Score and the ESG report for two periods after 2015 represents the trigger for missing observation elimination. Finally, the companies subject to double listing were eliminated, and the data used refer to the index of the country at which the firm belongs (Table 1). After the application of this filter, the initial set of firms has been reduced to 111 elements.

Table 1: Initial Dataset Composition

Number of firms	Index	N. Firms
50	EUROSTOXX	15%
20	BEL 20	6%
40	CAC40	12%
30	DAX30	9%
100	FTSE100	30%
35	IBEX	10%
20	SMI	6%
40	FTSE MIB	12%
335	**Sum**	**100%**

In order to develop a sectorial-based analysis we collected firm sector data from Bloomberg using *Bloomberg Industry Classification Systems* (BICS). This system starts from 10 macro sectors and incrementing the level of detail, up to seven different subcategories, it is possible to observe 2.294 unique sectors. With the objective of studying non-financial firms,

due to a different composition in terms of balance sheet items, we have decided to use only the BICS first level of classification and financial sector has been excluded from our analysis because this study aim to analyze non-financial firms (Table 2).

Table 2: Final Dataset Composition

Code	Sectors	N	%
MAT	Materials	16	14%
DIS	Consumer Discretionary Products	16	14%
IND	Industrials	18	16%
HEA	Health care	12	11%
TEC	Technology	9	8%
CON	Consumer Staples	13	12%
COM	Communication	11	10%
ENE	Energy	5	5%
UTI	Utilities	11	10%
	Sum	**111**	**100%**

We developed our analysis considering the Altman Z-Score as a proxy of firm intrinsic riskiness expressed by the balance sheet and income statement items. Due to the composition of Z-Score, we use this variable as a summary indicator of its main components: (i) working capital; (ii) total assets; (iii) retention of profits; (iv) EBIT; (v) market capitalization; (vi) total liabilities; (vii) turnover (Altman 1968). According to the statical model presented below, we approximate firm riskiness through Bloomberg probability of default, evaluated on 5 different yearly configurations and calculated as Merton's distance to default. These items represent the dependent variables of our regressions. With the objective of assessing the contribution of environment, social and governance *performance* in reducing the probabilities of default of the firms belonging to our sample, we collected the overall ESG *score*, the environment score, the governance score, and the social score from Bloomberg. Finally, and as mentioned above, the codes of the sectors to which the companies considered belong were collected (Table 3).

Table 3: List of variables considered

Code	Variable	Source	Variable
B1Y	Bloomberg PD 1 year	Bloomberg	Dependent Variable
B2Y	Bloomberg PD 2 years	Bloomberg	Dependent Variable
B3Y	Bloomberg PD 3 years	Bloomberg	Dependent Variable
B4Y	Bloomberg PD 4 years	Bloomberg	Dependent Variable
B5Y	Bloomberg PD 5 years	Bloomberg	Dependent Variable
ZSC	Altman Z-Score	Bloomberg	Regressor
ENV	Environment Disclosure	Bloomberg	Regressor
GOV	Governance Disclosure	Bloomberg	Regressor
SOC	Social Disclosure	Bloomberg	Regressor
ESG	ESG Total Disclosure	Bloomberg	Regressor
BIC	Bloomberg Industry Classification System	Bloomberg	Regressor (set of dummies)
MKT	Market Capitalization	Bloomberg	Control Variable
LEV	Leverage	Bloomberg	Control Variable
ETA	Earnings on Total Assets	Bloomberg	Control Variable

The final sample is represented by an unbalanced panel dataset, this is due to a temporal mismatching that characterized the residual firms after the application of the filter selection. As result of the filters, the analysis is based on 10.410 different observations. In the table below are represented the principal summary statistics: mean; variance; standard deviation; quartiles (Table 4).

Table 4: Statistical Summary

	ZSC	B1Y	B2Y	B3Y	B4Y	B5Y	ENV	GOV	SOC	ESG
Mean	3,15	0,21%	0,67%	1,23%	1,76%	2,29%	43,48	61,53	51,66	49,60
Variance	7,88	0,01%	0,03%	0,05%	0,07%	0,08%	227,08	84,16	201,40	135,60
Standard Deviation	2,81	1,21%	1,79%	2,26%	2,60%	2,82%	15,07	9,17	14,19	11,64
Minimum	0,05	0,00%	0,01%	0,06%	0,15%	0,33%	2,33	26,79	8,77	11,57
1st Quartile	1,55	0,00%	0,07%	0,25%	0,49%	0,83%	34,11	57,14	43,86	43,39
Median	2,55	0,02%	0,25%	0,63%	1,06%	1,55%	44,72	62,50	54,39	50,83
3rd Quartile	3,94	0,09%	0,64%	1,35%	2,02%	2,65%	55,81	67,86	61,40	57,85
Maximum	38,63	25,59%	33,71%	38,52%	41,44%	43,04%	79,07	96,24	85,96	77,27

3.2 Research Design

With the objective of proving a different contribution of ESG score on firms' probability of default we implemented a set of difference-in-difference analysis. For each probability of default described above we developed a difference in difference regression, evaluating the impact of the introduction of ESG metrics into default likelihood assessment process.

According to Fama, we assume that European stock market benefit from strong efficiency, so market prices and values express a good approximation of firms' characteristics and probabilities of default (Fama, 1970). In this sense, the inclusion of ESG *metrics* into the difference-in-difference analysis grant us to discover a differential risk observed among treatment and control group (Woolridge and Imbens, 2009).

As exogenous event we consider the Paris Climate Agreement held in December 2015. We assume that after that occurrence, a broader interest on sustainability spreads on the market, affecting the estimation of default probabilities of firms. The treatment group is represented by firms with an ESG score greater than 50, while control group otherwise.

In order to verify *hypothesis 1*, we applied the following model to all the five yearly probabilities of default introduced in the precedent section:

$$PD_{it} = \alpha + ß_1 * ZSC_{it} + ß_2 * ENV_{it} + ß_3 * SOC_{it} + ß_4 * GOV_{it} + \sum_{c=1}^{3} \partial_c * Bank\ Controls_{it} + \gamma_1 * D_{time_{it}} + \gamma_2 * D_{trm_{it}} + \lambda_1 * D_{trm_{it}} * D_{time_{it}} + \alpha_k + \alpha_j + u_{it} \quad \text{(i)}$$

with: (i) PD_{it} = probability of *default* with yearly time frame *t*, (t=1;2;3;4;5); (ii) α = constant; (iii) ZSC_{it} = Z-Score; (iv) ENV_{it} = environmental score; (v) SOC_{it} = social score; (vi) GOV_{it} = governance score; (vii) $D_{time_{it}}$ = dummy which takes a value of 1 for the years after 2014 and 0 in the other cases; (viii) $D_{trm_{it}}$= dummy which takes value 1 in the group of companies treated and 0 in the rest; (ix) $D_{trm_{it}} * D_{tm_{it}}$ = interaction variable that assumes a value of 1 in the case of companies belonging to the treatment group for the years after 2014; (x) α_k= industry fixed-effect; (xi) α_j= time fixed-effect; (x) u_{it} = error term.

The model proposed is able to assess changes in the probability of default as a function of the risk expressed by financial statements, corrected for the time factor and adjusted for ESG score. We present in the table below the logic model implemented (*Table 5).* The coefficients of interest are represented by the time effect (γ_1), the treatment effect connected to ESG score (γ_2) and the interaction among ESG score and time effect (λ_1). This latter will be computed for each yearly probability of default and comparing the values of λ_{1t} it is possible to validate or reject *hypothesis 1*.

Table 5: Difference in difference model framework implemented (excluding covariates ß1, ß2, ß3, ß4).

	Before ESG (2010-2015)	*After ESG (2015-2020)*	*After - Before*
Control Firms	α	$\alpha + \gamma_1$	γ_1
Treatment Firms	$\alpha + \gamma_2$	$\alpha + \gamma_1 + \gamma_2 + \lambda_1$	$\gamma_1 + \lambda_1$
Control - Treatment	γ_2	$\gamma_2 + \lambda_1$	λ_1

With the aim of verify *hypothesis 2* we have modified the previous *difference-in-difference* regression adding a set of eight dummies representing the nine macro-sectors that constitutes *Bloomberg Industry Classification Systems* (BICS). We remind that financial sector firms are excluded in our analysis, and we can omit a dummy because it is expressed in the constant coefficient.

$$PD_{it} = \alpha + ß_1 * ZSC_{it} + ß_2 * ESG_{it} + \sum_{s=1}^{8} \delta_s * Sector_{it} + \sum_{c=1}^{3} \partial_c * Bank\ Controls_{it} + \gamma_1 * D_{time_{it}} + \gamma_2 * D_{trm_{it}} + \lambda_1 * D_{trm_{it}} * D_{time_{it}} + \alpha_k + \alpha_j + u_{it}$$

with: (i) PD_{it} = probability of *default* with yearly time frame *t*, (t=1;2;3;4;5); (ii) α = constant and utility sector given the omission of a sector; (iii) ZSC_{it} = Z-Score; (iv) ESG_{it} = ESG score; (v) MAT_{it} = dummy for materials sector; (vi) DIS_{it} = dummy for discretionary product sector; (vii) IND_{it} = dummy for industrial sector; (viii) HEA_{it} = dummy for health sector; (ix)

TEC_{it} = dummy for technology sector; (x) CON_{it} = dummy for consumer staple sector; (xi) COM_{it} = dummy for communication sector; (xii) ENE_{it} = dummy for energetic sector; (xiii) $D_{time_{it}}$ = dummy which takes a value of 1 for the years after 2014 and 0 in the other cases; (xiv) $D_{trm_{it}}$= dummy which takes value 1 in the group of companies treated and 0 in the rest; (xv) $D_{trm_{it}} * D_{tm_{it}}$ = interaction variable that assumes a value of 1 in the case of companies belonging to the treatment group for the years after 2014; (xvi) α_k= industry fixed-effect; (xvii) α_j= time fixed-effect; (xviii) u_{it} = error term.

4. *Results*

The application of the econometric model leads to the results shown in the table below (Table 7). For each probability of default, the multiple null hypothesis on all coefficients can be rejected given a negligible value for the p-value associated to the F-statistic. The coefficient λ_1 has a statistical significance at least of 99% in each regression. We can confirm the tendency, found in literature, with which an increase in ESG score generate a reduction of firms' default likelihood.

The magnitude of λ_1 expresses the contribution of ESG score in reducing firm risk and it is possible to observe a greater impact of environmental, social and governance scoring on PD of longer time horizons. We can interpret this result as a time lag with which any action, that involves an improvement of the current ESG score, takes to become effective. For example, an internal redesign processes oriented to pollution reduction is characterized by an immediate initial cost and a sequence of benefits, monetary and reputational that will affect firm's riskiness and profitability on the long run. Analyzing the results of 5 years PD the coefficient representative of the interaction among time and treatment has a significance greater than 99.99%.

The Altman Z-Score, differently as found in the previous literature, do not any assume statistical relevance in predicting the likelihood of default of firms. Higher value of Z-Score expresses a low level of riskiness but we remind that this information is a synthesis of balance sheet items and cannot be influence by exogenous event or point out qualitative

information such as, disruptive changes in customer preferences or a lack of foresight of business strategy.

In order to enrich the model and involve the qualitative dimensions of environmental safeguard, governance, and social issue we implemented into the model three ESG scoring indicators.

Coherently with the reference literature we have found that the environmental pillar assumes the greatest importance in term of risk mitigation effect (Gibson et al., 2021; Aslan et al., 2021). Furthermore, it is possible to observe that these coefficients follow a convex u-shaped expansion with a vertex corresponding to the two-year probability of default. We can justify this phenomenon as a possible time delay in environmental policy implementations and market process pricing. More specifically, environmental pillar level improvements require time to be observed on the market.

The social score is significant only for 5 years default probability. Its main components are: workforce; human rights; community; product responsibility. So, it possible to observe that the improvement of employed working condition, the enlargement of employees' skills, human rights guarantee, the development of a community and the design of a more sustainable production cycle have a relevant impact on corporate reputation. In this way, as corporate reputation increases and solid-lasting relationship with stakeholders are built, it possible to affirm that company riskiness decrease. For longer probability of defaults, the contribution of risk mitigation is greater than short-term *PD.* Consequently, we can confirm that the benefit of social issue improvements generates greater impacts on the long term, and it is verified the truthfulness of hypothesis 1.

Governance coefficient is not statistically significant, and this can may be caused by firms' selection criteria.

Table 7: Difference-in-difference, time only analysis

Model 1						Model 2					
	PD1	**PD2**	**PD3**	**PD4**	**PD5**		**PD1**	**PD2**	**PD3**	**PD4**	**PD5**
Intercept	0,062	0,313 ***	0,178 **	0,259 **	0,331 **	Intercept	0,062	0,14 **	0,304 ***	0,128	0,174
	0,111	0,068	0,089	0,123	0,138		0,095	0,059	0,086	0,106	0,119
ZSC	0,008	0,007	0,01	-0,005	-0,016	ZSC	0,009	0,008	0,015	-0,003	-0,013
	0,009	0,022	0,032	0,04	0,045		0,01	0,021	0,032	0,039	0,044
ENV	-0,013 *	-0,034 **	-0,025 **	-0,019 ***	-0,022 ***	ESG	-0,019 ***	-0,043 ***	-0,021 ***	-0,027 ***	-0,032 ***
	0,007	0,015	0,006	0,007	0,008		0,007	0,011	0,008	0,010	0,012
SOC	-0,005	-0,012	-0,024	-0,022	-0,041 *	COM*ESG	0,091	0,059	0,093	0,122	0,145
	0,006	0,013	0,018	0,023	0,025		0,078	0,047	0,07	0,087	0,097
GOV	-0,002	-0,019	-0,041 *	-0,027 *	-0,019**	CON*ESG	0,039	0,048	0,089	0,121	0,144
	0,007	0,017	0,023	0,015	0,008		0,071	0,043	0,064	0,078	0,088
MKT	-0,009 ***	-0,012 ***	-0,013 ***	-0,015 ***	-0,017 ***	DIS*ESG	0,033	0,063	0,079	0,081	0,078
	0,001	0,001	0,002	0,003	0,004		0,079	0,048	0,071	0,087	0,098
LEV	-0,013	-0,01	-0,018	-0,026	-0,033 *	ENE*ESG	0,052	0,145 **	0,227 *	0,286 *	0,324 *
	0,014	0,009	0,013	0,017	0,018		0,038	0,073	0,125	0,15	0,178
ETA	0,039 ***	0,072 ***	0,025 ***	0,029 ***	0,031 ***	HEA*ESG	0,005	-0,008	0,048	0,071	0,085
	0,003	0,002	0,002	0,003	0,003		0,075	0,046	0,068	0,086	0,093
time	0,102 *	0,137 **	0,134 **	0,12	0,098	IDS*ESG	0,091	0,077 *	0,129 *	0,154 *	0,202 **
	0,056	0,064	0,066	0,077	0,082		0,071	0,043	0,073	0,089	0,103
treat.	-0,013	-0,036	-0,1	-0,115	-0,139	MAT*ESG	0,096	0,086 *	0,144 *	0,192	0,223 *
	0,029	0,066	0,096	0,119	0,134		0,074	0,046	0,074	0,098	0,116
λ_1	-0,094 ***	-0,178 ***	-0,231 ***	-0,265 ***	-0,292 ***	TEC*ESG	0,022	0,125 **	0,063	0,087	0,103
	0,026	0,041	0,061	0,074	0,083		0,08	0,049	0,072	0,089	0,1
						MKT	-0,009 ***	-0,011 ***	-0,012 ***	-0,013 ***	-0,016 ***
							0,001	0,001	0,002	0,004	0,004
						LEV	-0,015	-0,013	-0,022 *	-0,031 *	-0,04 *
							0,014	0,008	0,013	0,016	0,021
						ETA	0,037 ***	0,072 ***	0,026 ***	0,031 ***	0,034 ***
							0,003	0,0016	0,002	0,003	0,003
						time	0,097 **	0,128 **	0,124 **	0,11 **	0,103 **
							0,046	0,064	0,06	0,055	0,048
						Treat.	0,043	0,04	0,071	0,099	0,121
							0,028	0,063	0,093	0,115	0,128
						λ_1	-0,093 ***	-0,179 ***	-0,236 ***	-0,275 ***	-0,299 ***
							0,027	0,055	0,058	0,071	0,08
R^2	0,144	0,200	0,226	0,241	0,251	R^2	0,151	0,207	0,232	0,246	0,257

R^2 Adj.	0,139	0,195	0,222	0,236	0,247	R^2 Adj.	0,143	0,199	0,224	0,238	0,249
F test	29,73 ***	43,68 ***	50,79 ***	54,84 ***	57,98***	F test	18,43 ***	26,69 ***	30,78 ***	33,08 ***	34,86***
on			df = 10; 1979			on			df=17;1972		
Industry effect	yes	yes	yes	yes	yes	Industry effect	yes	yes	yes	yes	yes
Time effect	yes	yes	yes	yes	yes	Time effect	yes	yes	yes	yes	yes

Note: * p < 0.1; ** p < 0.05; *** p <0.01

In the second model, we focused on the combined effect of ESG overall score and sector variable on firms' probabilities of default. Regarding the ESG score risk mitigation effect, it is possible to observe that the ESG regression coefficient assumes negative values and follows the same u-shape expansion observed for the environmental pillar in model 1. Therefore, we can conclude that the effects produced by any ESG score enhancement are more relevant for a two-year-based probability of default. Furthermore, it is possible to observe a coefficient increase on longer time horizons, as observed for the social score pillar. Additionally, the overall ESG score presents a statistical relevance of 99% for each PD extension.

A dummy variable represents each sector, and we omitted the variable referred to as the utility sector so that the model's intercept can capture this dimension. This way, it is possible to interpret each sectorial coefficient as the increase in the probability of default concerning the riskiness expressed by the utility sector. Based on empirical analysis, we can affirm that there is no statistical significance for the following sectors: communication, consumer staples; discretionary products; health, and technology. The utility sector, expressed by the intercept, presents a time-growing coefficient with a confidence interval more significant than 99% for four- and five-year default probabilities. A more linear growth trend can be observed for the energetic sector. Each extension of the time horizon leads to an increase in the probability of default. The rationale of the phenomenon could be explained by the intrinsic exposure of the energy sector to sustainability issues e renewable energy sources. More attention was paid since the Paris agreement on climate could generate a more sensitivity of firms belonging to the energetic sector, affecting the

probabilities of default observed on the market. This sector presents a confidence interval of 90% except for the one-year PD.

Industrial and material sectors seem to follow the lead defined by the energy sector but with a lower magnitude in charge of their regression coefficients. Even if the absolute value of the coefficients increases as the default likelihood timeframe expands, the contribution to the PD is less remarkable on each time horizon. The confidence interval for both sectors is 90% for each time horizon greater or equal to three years.

Even in this model, the F-test evaluated on the multiple null hypotheses on each regressor is rejected for each time extension of the default probabilities: the F-test is remarkably more significant than the critical value, with a confidence interval of 99%. The adjusted R-squared grows along with the expansion of the time frame considered to evaluate default probabilities.

The coefficient expression of the interaction among time and treatment assumes negative values and a statistical significance of 99% for each PD time extension. These values can be interpreted as the risk mitigation effect between enterprises that do not implement ESG strategies before the exogenous shock and firms that realize ESG policies after the event represented by the Paris agreement on climate. However, even in this case, the regression coefficient increases in absolute values and the time extension considered. This means that the risk mitigation effect is more prominent for the medium-long term than the short term.

We first checked if default probabilities could be shifted prior to the Paris Agreement, for example, due to market conditions. In order to do so, we introduced a fake Paris Agreement in 2012, and the sample was restricted to the period 2010-2014, before the effective Paris Agreement. For both models, the coefficients interacted with "fake PA" present a negative value but without any statistical confidence (Table 8).

Secondly, we checked for the absence of multicollinearity among regressors, and to achieve this goal, we assessed the variance inflation factor (VIF). In this way is possible to affirm that there are no regressors with a VIF superior to 5, the critical value set for this test (Table 9).

Table 8: Placebo Test

	Model 1						Model 2				
	PD1	**PD2**	**PD3**	**PD4**	**PD5**		**PD1**	**PD2**	**PD3**	**PD4**	**PD5**
Intercept	0,055	0,13***	0,274**	0,123**	0,162**	Intercept	0,051	0,13***	0,274***	0,123	0,162
	0,077	0,066	0,074	0,116	0,136		0,077	0,047	0,073	0,101	0,106
ZSC	0,008	0,007	0,014	-0,003	-0,011	ZSC	0,008	0,007	0,014	-0,003	-0,011
	0,008	0,019	0,028	0,037	0,037		0,008	0,019	0,028	0,037	0,037
Fake PA	0,083*	0,115*	0,113**	0,099*	0,09	Fake PA	0,083*	0,115*	0,113**	0,099**	0,091**
	0,043	0,061	0,056	0,046	0,041		0,043	0,061	0,056	0,046	0,041
Fake						Fake PA					
PA*ENV	-0,012	-0,026	-0,015	-0,018	-0,023	*ESG	-0,012	-0,026	-0,015	-0,018	-0,023
	0,01	0,018	0,011	0,015	0,016		0,01	0,018	0,011	0,015	0,016
Fake											
PA*SOC	-0,016	-0,037	-0,021	-0,024	-0,031	ESG	-0,016**	-0,037***	-0,021***	-0,024**	-0,031***
	0,006	0,009	0,007	0,01	0,011		0,006	0,009	0,007	0,01	0,011
Fake											
PA*GOV	0,09	0,057	0,087	0,12	0,144	COM*ESG	0,09	0,057	0,087	0,12	0,144
	0,076	0,038	0,069	0,081	0,088		0,076	0,038	0,069	0,081	0,088
ENV	0,033	0,041**	0,071**	0,116**	0,141***	CON*ESG	0,033	0,04	0,071	0,116*	0,141*
	0,064	0,04	0,057	0,063	0,084		0,064	0,04	0,057	0,063	0,084
SOC	0,029	0,055	0,069	0,066	0,068*	DIS*ESG	0,029	0,055	0,069	0,066	0,068
	0,066	0,039	0,061	0,073	0,092		0,066	0,039	0,061	0,073	0,092
GOV	0,05	0,123	0,188	0,263*	0,266	ENE*ESG	0,05	0,123*	0,188*	0,263*	0,266*
	0,032	0,067	0,113	0,149	0,158		0,032	0,067	0,113	0,149	0,158
MKT	0,004	-0,007	0,044	0,068***	0,071***	HEA*ESG	0,004	-0,007	0,044	0,068	0,071
	0,068	0,039	0,061	0,081	0,079		0,068	0,039	0,061	0,081	0,079
LEV	0,078	0,075	0,104	0,125	0,213*	IDS*ESG	0,078**	0,075	0,104	0,125	0,237**
	0,069	0,035	0,064	0,087	0,095		0,069	0,035	0,064	0,087	0,095
ETA	0,086	0,073	0,137	0,161	0,205	MAT*ESG	0,086	0,073**	0,137**	0,161*	0,205*
	0,064	0,037	0,064	0,086	0,111		0,064	0,037	0,064	0,086	0,111
treatment	0,022	0,106	0,062	0,083	0,084	TEC*ESG	0,022	0,106**	0,062	0,083	0,084
	0,078	0,043	0,068	0,083	0,092		0,078	0,043	0,068	0,083	0,092
λ_1	-0,008	-0,011***	-0,01***	-0,011***	-0,015***	MKT	-0,008	-0,011	-0,01	-0,011***	-0,015***
	0,001	0,001	0,002	0,004	0,004		0,001	0,001	0,002	0,004	0,004
						LEV	-0,012	-0,01	-0,022*	-0,025*	-0,034*
							0,014	0,008	0,012	0,014	0,018
						ETA	0,032	0,067	0,022	0,029	0,031
							0,021	0,015	0,023	0,028	0,032
						treatment	0,037	0,036	0,06	0,091	0,102
							0,023	0,062	0,085	0,094	0,116
						λ_1	-0,086***	-0,143***	-0,222***	-0,223***	-0,281***
							0,023	0,047	0,051	0,062	0,074
R2	0,107	0,142	0,172	0,171	0,183	R2	0,110	0,153	0,167	0,192	0,182
R2 Adj.	0,106	0,150	0,171	0,184	0,180	R2 Adj.	0,107	0,159	0,161	0,188	0,194
F-Statistic	22,599	33,203	39,111	43,878	46,386	F-Statistic	13,274	20,023	22,780	24,482	26,494
on			df = 13; 775			on			df=17;771		

Industry effect	yes	yes	yes	yes	yes	Industry effect	yes	yes	yes	yes	yes
Time effect	yes	yes	yes	yes	yes	Time effect	yes	yes	yes	yes	yes

Note: * p < 0.1; ** p < 0.05; *** p <0.01

Table 9: We present the results of the variance inflation factor.

	ZSC	ENV	SOC	GOV	MKT	LEV	ETA
Model 1 (ENV + SOC + GOV)	0,908	1,842	1,719	1,132	0,980	0,906	0,864
	ZSC	ESG	MKT	LEV	ETA		
Model 2 (ESG)	0,854	0,961	0,978	0,905	0,869		

5. *Conclusions*

From the analysis described above it possible to verify the tendency observed in literature with which a firm is able to reduce its own probability of default through the improvement of ESG score. Not every component of ESG scoring has the same importance, in fact the environmental sphere accounts for the most in the enhancement of firms' credit worthiness. This conclusion is restricted only to the time-based analysis. In fact, with regards to a joint time-sectorial analysis, the social dimension accounts only for the reduction of 5-year probabilities of default. For each default likelihoods the major contribution is given by environmental score improvements.

Our first contribution concerns the confirmation that the default risk mitigation effect increases as the default likelihood reference time increases. Banks can adequately assess firms' credit worthiness involving adjusted probabilities of default for ESG score with time spans greater than 1 year. Through the validation of *hypothesis 1* we have also identified the existence of a time lag between ESG compliant strategies and the effects on firms' probability of default. This lag is generated by the dynamics linked to reputation; any improvement that impact on corporate dimension require a non-negligible amount of time to be perceived by the market. The assumption of strength information efficiency consequently cannot hold.

The second contribution refers to the existence of a differential effect in firms' risk mitigation effect in function of the sector at which a company belongs. The implication of the truthfulness of *hypothesis 2* is connected to banks' risk allocation strategies: banks can dynamically define the amount of capital that they desire to allocate on a specific sector and geographical area, coherently with their risk appetite framework, and adjust their allocation according to sectorial sensibility to ESG scoring improvement. The process can also be enriched by the implementation of sensitivity analysis focused on how overall loan portfolio risk exposure will change according to marginal ESG score variation and sectorial allocation.

ESG risks can potentially affect bank profitability and solvency, so EBA included this risk class into the Supervisory Review and Evaluation Process (SREP). This imply that the supervisory authority is able to assess banks' business model feasibility also analyzing the ESG dimension in the evaluation.

Generally, ESG and environmental regression coefficients follow a u-shaped progression as the time horizon expands. A further contribution is linked to difference-in-difference results: short-medium term default probabilities are sensible to improvements in ESG scores; in fact, the regression coefficient of the interaction among time and treatment manifests a statistical significance of 99%. Due to a negative value in charge of the interaction coefficient, it is possible to demonstrate the existence of the risk mitigation raised by ESG score performance developments.

The present study is characterized by model limits: (i) we assume that Z-score is able to express the entire profile of risk represented by balance sheet items, but it doesn't consider the financial statement, the risk appetite framework and the strategic plan; (ii) the sample refers only to European listed companies, but we do not consider different geographical area neither SME; (iii) probabilities of default are strictly correlated with market cycles dynamics; (iv) the time period took in consideration is characterized by unconventional monetary policy, such as, negative interest rates and quantitative easing. More specifically, negative interest rates reduce the cost of borrowing, which can encourage firms to invest and expand their operations. Quantitative easing, on the other hand, involves

the central bank buying financial assets from the market, which increases the money supply and reduces borrowing costs. The implementation of these monetary policies can have a direct impact on the credit risk of firms. For example, lower borrowing costs can reduce the likelihood of default for firms, as they are able to access cheaper financing. Additionally, quantitative easing can also boost financial market conditions, which can improve the overall creditworthiness of firms.

Future studies could try to implement a sensitivity analysis to reveal the influence of exogenous variables on probability of defaults. In addition, observing a more geographically diversified sample verify the persistence of the time lag effect in risk mitigation effect.

6. Bibliography

Altman E.I., (1968), "Financial ratios, discriminant analysis and the prediction of corporate bankruptcy", *The Journal of Finance*, Vol. 23, pp. 594-596.

Aslan A., Poppe L., Posch P., (2021), "Are Sustainable Companies More Likely to Default? Evidence from the Dynamics between Credit and ESG Ratings", *Sustainability, 13, p. 8568. https://doi.org/10.3390/su13158568*

Avetisyan E., Hockerts K., (2017), "The Consolidation of the ESG Rating Industry as an Enactment of Institutional Retrogression", *Business Strategy and the Environment*, Vol. 26, pp. 316-330

Baker H. K., Haslem J.A., (1974), "The impact of investor socioeconomic characteristics on risk and return preferences.", *Journal of Business Research*, Vol. 2, N. 4, pp. 469-476.

Barth F., Hübel B., Scholz H., (2021), "ESG and corporate credit spreads", *SSRN papers*, pp. 2-4.

Berg F., Koelbel J. F., Rigobon R., (2019), "Aggregate Confusion: The divergence of ESG ratings", *MIT Sloan School Working Paper,* N. 5822/19, pp. 28-33.

Berntsson W., (2019), "The impact of ESG score on firm's cost of capital and riskiness"

Bettis R. A., Mahajan V., (1985), "Risk/return performance of diversified firms.", *Management Science*, Vol. 31, N. 7, pp. 785-799.

Bhattacharya S., Sharma D., (2018), "Do environment, social and governance performance impact credit ratings: a study from India", *International Journal of Ethics and Systems*, Vol. 35, N. 3, pp. 479-481.

Brown T.J., Dacin P.A., (1997), "The company and the product: corporate associations and consumer product responses", *Journal of Marketing*, Vol. 61, pp. 68–84.

Campbell J. Y., Viceira L.M., (2005), "The term structure of the risk–return trade-off.", *Financial Analysts Journal*, Vol. 61, N. 1, pp. 34-44.

Blancard C.G., Crifo P., Diaye M.A., Scholtens B., Oueghlissi R., (2016), "Environmental, Social and Governance (ESG) Performance and Sovereign Bond Spreads: An Empirical Analysis of OECD Countries", *SSRN*. http://dx.doi.org/10.2139/ssrn.2874262

Cash D., (2018), "Can credit rating agencies play a greater role in corporate governance disclosure?", *Corporate Governance*, Vol. 18, No. 5, pp. 960-964.

Chang K., Kim I., Li Y., (2014), "The heterogeneous impact of corporate social responsibility activities that target different stakeholders", *Journal of Business Ethics*, Vol. 125, pp. 211–234.

Chiaramonte L., Dreassi A., Girardone C., Piserà S., (2021), "Do ESG strategies enhance bank stability during financial turmoil? Evidence from Europe", *The European Journal of Finance*, 28:12, pp. 1173-1211, DOI: 10.1080/1351847X.2021.1964556

Christensen D. M., Serafeim G., Sikochi A, (2021), "Why is Corporate Virtue in the Eye of the Beholder? The Case of ESG Ratings", *The Accounting Review*, pp. 34-35.

Clarkson M.E., (1995), "A stakeholder framework for analyzing and evaluating corporate social performance", *The Academy of Management Review,* Vol. 20, pp. 92–117.

De Santis A., Di Marzo G., Fasano D., Marlino M., Nigro B., (2020), "Pricing risk adjusted: il ruolo dei parametri ESG", *PE Working Paper*, Vol. 20, pp. 40-45.

Devalle A., Fiandrino S., Cantino V., (2017), "The Linkage between ESG Performance and Credit Ratings: A Firm-Level Perspective Analysis", *International Journal of Business and Management*, Vol. 12, N. 9, pp. 53-65.

Donaldson T., Preston L.E., (1995), "The stakeholder theory of the corporation: concepts, evidence, and implications", *The Academy of Management Review,* Vol. 20, pp. 65–91.

Duffie D., Saita L., Wang, K., (2007), "Multiperiod corporate default prediction with stochastic covariates", *Journal of Financial Economics*, Vol. 83, pp. 635–665.

EBA:

- (2019), Draft Guidelines on loan origination and monitoring, Consultation Paper, EBA, p. 7.
- (2020a), Guidelines on loan origination and monitoring, EBA.
- (2020b), Explanatory note on the EBA comprehensive approach to loan origination, EBA.
- (2020c), EBA Discussion Paper on management and supervision of ESG risks for credit institutions and investment firms.
- (2021), EBA Discussion Paper on Management and supervision of ESG risks for credit institutions and investment firms. Explanatory note on the EBA comprehensive approach to loan origination, EBA.

Eccles R.G., Krzus M., Rogers J., Serafeim G., (2012), "The need for sector-specific materiality and sustainability reporting standards", *Journal of Applied Corporate Finance*, Vol. 24, pp. 65–71.

Fama E.F., (1970), "Efficient Capital Markets: A Review of Theory and Empirical Work.", *The Journal of Finance*, Vol. 25, N. 2, pp. 383–417.

Fama E.F., (1971), "Risk, return, and equilibrium.", *Journal of Political Economy*, Vol. 79, N. 1, pp. 30-55.

Freeman R.E., (2010), "Strategic management: a stakeholder approach", *Cambridge University Press*, Cambridge, p. 25.

Garcia A. S., Wesley M.D.S., Renato J.O., (2019), "Corporate sustainability, capital markets, and ESG performance." *Individual behaviors and technologies for financial innovations*, Springer, pp. 287-309.

Gibson R., Krueger P., Schmidt P.S., (2021), "ESG rating disagreement and stock returns", *Swiss Finance Institute Research Paper Series*, Vol. 19, N. 67, pp 25-27.

Greening D.W., Turban D.B., (2000), "Corporate social performance as a competitive advantage in attracting a quality workforce", *Business & Society*, Vol. 39, pp. 254–280.

Gubareva, M. (2021), "How to estimate expected credit losses – ECL – for provisioning under IFRS 9", *Journal of Risk Finance*, Vol. 22 No. 2, pp. 169-190.

Henisz W.J., McGlinch J., (2019), "ESG, Material Credit Events, and Credit Risk", *Journal of Applied Corporate Finance*, Vol. 32, N. 2, pp. 116-117.

Höck A., Klein C., Landau A., Zwergel B., (2020), "The effect of environmental sustainability on credit risk", *Journal of Asset Management*, Vol. 21, pp. 90–91.

Hübel B., (2020), "Do Markets Value ESG Risks in Sovereign Credit Curves?", *Quarterly Review of Economics and Finance*, pp. 18-23.

Ielasi F., Ceccherini P., Zito P., (2020), "Integrating ESG Analysis into Smart Beta Strategies", *Sustainability*, Vol. 12, pp. 13-14.

Ingo W., (2020), "Sense and Nonsense in ESG Ratings", *SSRN papers*, pp. 37-40.

Jang G., Kang H.G., Lee J.Y., Bae K., (2020), "ESG Scores and the Credit Market", *Sustainability*, Vol. 12, pp. 2-11.

Kiesel F., Lücke F., (2019)," ESG in credit ratings and the impact on financial markets", *Financial Market Institutions & Instruments*, Vol. 28, N. 3, pp. 276-277.

Kim S., Kumar N., Lee J., Oh J., (2021), "ESG Lending", *SSRN papers,* pp. 16-20.

Kim S., Li Z., (2021), "Understanding the Impact of ESG Practices in Corporate Finance", *Sustainability*, Vol. 13, pp. 13-14.

Klein C., (2019), "Quantitative Credit-Rating Models Including ESG Factors", *The Journal of Environmental Investing*, Vol. 01, pp. 14-16.

Latino C., Pelizzon L., Rzeznik A., (2021), "The power of ESG ratings on stock markets", *SSRN papers*, pp. 20-21.

Li P., Zhou R., Xiong Y., (2020), "Can ESG Performance Affect Bond Default Rate? Evidence from China", *Sustainability*, Vol.12, N. 2954, p. 10.

Liang H., Renneboog L., (2017), "On the foundations of corporate social responsibility", *The Journal of Finance*, Vol. 72, N. 2, pp. 898–904.

McGuire J.B., Sundgren A., Schneeweis T., (1988), "Corporate social responsibility and firm financial performance", *The Academy of Management Review,* Vol. 31, pp. 854–872.

Michalski L., Low R. K. Y., (2020), "Corporate credit rating feature importance: Does ESG matter?", *SSRN papers*, pp. 53-54.

United Nations, (2015), "Paris agreement.", *Report of the Conference of the Parties to the United Nations Framework Convention on Climate Change (21st Session, 2015),* Paris.

United Nations, (2015), "Transforming our world: the 2030 Agenda for Sustainable Development.", New York.

Oikonomou I., Brooks C., Pavelin S., (2012), "The impact of corporate social performance on financial risk and utility: a longitudinal analysis", Financial Management, Vol. 41, pp. 483–515.

Olmedo E.E., Fernández-Izquierdo M.A., Ferrero I., Rivera-Lirio J.M., Muñoz-Torres M.J., (2019), "Rating the Raters: Evaluating how ESG Rating Agencies Integrate Sustainability Principles", *Sustainability*, Vol. 11, pp. 13-14.

Orlitzky M., Benjamin J.D., (2001), "Corporate social performance and firm risk: a meta-analytic review", Business & Society, Vol. 40, pp. 369–396.

Rocca E., (2021), "Valenza strategica della gestione dei rischi ESG", *Bancaria*, Vol. 4, pp. 59-65.

Sassen R., Hinze A.K., Hardeck I., (2016), "Impact of ESG factors on firm risk in Europe", *Journal of Business Economics*, Vol. 86, pp. 867–904.

Stellner C., Klein C., Zwergel B., (2015), "Corporate social responsibility and Eurozone corporate bonds: The moderating role of country sustainability", *Journal of Banking & Finance*, Vol. 59, p. 548.

Stubbs W.P.R., (2013), "Lifting the veil on environment-social-governance rating methods", *Social Responsibility Journal*, Vol. 9 N.4, pp. 636-637.

Turban D.B., Greening D.W., (1997), "Corporate social performance and organizational attractiveness to prospective employees", *The Academy of Management Journal*, Vol. 40, pp. 658–672.

Waddock A.W., Graves S.B., (1997), "The corporate social performance–financial performance link", *Strategic Management Journal*, Vol. 18, pp. 303–319.

Willem S., (2016), "Integrating ESG into valuation models and investment decisions: the value-driver adjustment approach", *Journal of Sustainable Finance & Investment*, Vol. 6, N. 2, pp. 95-111.

Yang R., (2020), "Credit Ratings in the Age of Environmental, Social, and Governance (ESG)", *SSRN papers*, pp. 14-18.

Xu X., (2016), "Estimating Lifetime Expected Credit Losses Under IFRS 9", *SSRN papers*, pp. 20-21.

Wooldridge J. M., Imbens G. W., (2009), "Recent Developments in the Econometrics of Program Evaluation", *Journal of Economic Literature*, Vo. 47, N. 1, pp. 5–86.

Can ESG-oriented bank business model improve performance?

by

Palmieri[1], E.; Ferilli [2], G.B., Altunbas[3], Y., Stefanelli[2], V., Geretto[1], E.F.

[1]*University of Udine, Department of Economics and Statistics – Udine, Italy.*

[2]*University of Salento, Department of Economic Science – Lecce, Italy.*

[3]*Bangor University Business School – Bangor, Wales, United Kingdom.*

Abstract

Understanding how banks' performance is affected by their ESG-oriented business models is a challenging topic for academics, regulators, and practitioners. This paper fills the literature gap regarding the relationship between banks' business models (BMs) in interaction with ESG scores and banks' performance. To pursue this aim we perform a two stages analysis, first implement a clustering technique and then a GLS model. The analysis contributes to the literature on this relation by investigating a joint effect of each BMs identify with banks' ESG score with the aim to analyze the impact on banks' riskiness (probability of default, PD) and profitability (return on equity-ROE and return on asset-ROA). Our research design is applied to a sample of 329 worldwide banks with annual observation from 2007 to 2021. The paper's results show that the interaction between ESG performance and investing and wholesale banks' business model can mitigate banks' PD. On the other side, return on assets and return on equity could be increased by ESG performance enhancements of investing and retail banks, while for wholesale credit institutions we observe ROA reductions.

JEL Classification: G01 and G21

Keywords: *ESG-oriented bank business model, LOM, ESG score, bank performance, bank riskiness*

1. Introduction

The global financial crisis and ESG macro-trend have brought several implications in the banking industry. On one side, banking supervisory authorities have strengthened the banking regulation to assess and monitor the overdone vulnerability of the financial intermediates. Following this regulatory tightening, the study of banks' business models (BMs) has received growing attention by academics, practitioners, and regulators (BIS, 2022) to better understand their different configuration and investigate how they diverge with respect to banks' performance, efficiency, credit risk and solvency (Farnè and Vouldis, 2021).

On the other side, the EBA's guidelines on "loan origination and monitoring" (LOM) (European Banking Authority-EBA, 2020) lay the foundations for a paradigm shift in the banking sector, orienting the credit analysis and management processes toward a proactive model which are focusing on sustainable lending (Tirloni et al., 2020). In this perspective, banks have paid increasingly attention to Environmental, Social, and Governance (ESG) practices, with the aim to improve their market reputation and became "ESG-compliant". In fact, EBA LOM aims to strengthen banks' ability to assess customers' creditworthiness and emphasize the need to adopt credit risk management systems (EBA, 2020a; De Laurentis, 2021).

Hence, the integration of environmental sustainability in financial sector has become a topic of interest also for governments, legislators, and supervisory bodies (ECB, 2022). To this aim, European Commission published the document "Action Plan: Financing Sustainable Growth" to facilitate the spread of sustainable finance in the European context, while in for the banking perimeter the EBA supported the approach of sustainable development, introducing a taxonomy and fostering the adoption of unique approach for both the banking system and all financial institutions (EC, 2018; EBA, 2021).

Growing academic studies examine the macro topics above mentioned. In particular, many authors have investigated the relationship between business models characteristics and banks' performance. In this field, it is usual to implement clustering techniques (Amel

and Rhoades, 1988; Ayadi and Groen, 2014; Ayadi et al., 2016a; Ayadi et al., 2019; Ayadi et al., 2021;) to identify subgroups of banks characterized by a similar balance sheet composition. For instance, Farnè and Vouldis (2021), prove that banks following distinct BMs differ with respect to performance and risk indicators; while Ayadi et al (2021) found that banks with higher risk and lower profitability profile are more likely to change their business model ("migration").

Beside to these studies, a more recently strand of literature has focused on sustainable and ESG practices with cross-cutting applications on non-financial firms and banks perspective. Many scholars point out the positive impact of sustainable practices on banking performance, demonstrate their positive impact on bank's profitability (Wu and Shen, 2013), bank controversies management (Agnese et al., 2022; Galletta et al. 2022) or bank's cash flows and efficiency (Azmi et al., 2021).

On the riskiness side, studies have highlighted that banks' more ESG-oriented tend to be more resilient to economic downturns or exogenous shocks. Consistently, according to Chiaramonte at al. (2021), in time of financial turmoil, bank fragility can be mitigated through the adoption of ESG practices, while as showed by Di Tommaso and Thorton (2020) any improvement of the credit institution ESG profile can safeguard bank's risk taking.

However, we find a literature gap regarding studies on BMs assessment inclusive of bank's ESG profile to analyze the implication on credit institutions' performance.

Based on this primary evidence, we would broaden the knowledge matured in the previous literature making an interaction between these two components of analysis to offer an holistic evaluation of banks' BMs, ESG profile and performance. Hence, we outline the following research question (RQ):

RQ. *Do banks' business models linked to ESG score improve banks performance?*

To answer this research question, we applied cluster analysis algorithms and a GLS model on a sample of 329 worldwide banks with annual observations from 2007 to 2021. A former contribution of this paper is represented by the differently BM's impact on banks'

default probability considering multiple time horizons. Furtherly we measure the effect on banks' profitability ratios.

The remainder of the paper is structured as follows. In Section 2 we review the relevant literature. In Section 3 we describe our dataset variables and the methodological strategy. In Section 4 we illustrate and discuss our findings and robustness checks The last Section concludes our papers and summarizes implications for banking sectors and policy makers.

2. Literature Review

2.1 Literature review on banks' business models analysis and clustering

The literature on banks' business models (BMs) received growing attention from researchers, practitioners, and regulators (Farnè and Vouldis, 2021; Lagasio and Quaranta, 2022; BCE, 2018; EBA, 2018). After the 2008 financial crisis, interest was paid to the impact of systematic risk on banks' business models (BMs) and the likelihood that public bailout of institutions should be used as a crisis management tool (Passmore, 1985; Altunbas et al., 2011; Ayadi et al., 2021).

In these challenging research field, it is usual to implement clustering techniques based on the bank financial statements to classify the sample of analysis. This empirical approach is a focus of our study. The banks' groups thus identified are characterized by a similar balance sheet composition and are defined according to the orientation of the institution towards a retail or investing activities banks' BMs. From this perspective, Farnè and Vouldis (2021), implementing cluster analysis and identifying four business models, have provided evidence that the sets of banks following the distinct BMs differ with respect to performance and risk indicators. Similarly, Lagasio and Quaranta (2022), adding a connection analysis, have found that there is an association between the BMs adopting by bank and elements such as bank' size, profitability, efficiency, and risk profile. In particular, the choice could be affected by additional endogenous factors (i.e., bank financial statements items and operating strategy) and exogenous factors (i.e., financial crises and policies of central banks).

Some studies implementing a cluster analysis methodology have focused on the European banking system (Amel and Rhoades, 1988; Ayadi and Groen, 2014; Ayadi et al., 2016a; Ayadi et al., 2019; Ayadi et al., 2021). In this stream, Ayadi et al (2021) found that banks with higher risk and lower profitability are more likely to change their business model. In particular, the bank's BM migration positively affects bank performance (i.e., increase the profitability, stability, and cost efficiency). Although, market vulnerability may induce institutions to adapt their BM, these adjustments present a significant degree of stickiness. In contradiction to Ayadi et al (2021), some previous studies (ECB, 2016; ECB, 2018, EBA, 2018) have highlighted the tendency of banks not to migrate from different cluster following market shocks or significant environmental changes. These shreds of evidence underline a correlation between BM and bank's strategic plan, characterized by larger time horizons and slow adaptation times to changes.

Nevertheless, identifying the activities that characterize each BM has been the focus of existing studies (Ayadi & de Groen, 2014 Ayadi et al. 2015). For example, Ayadi et al. (2016b) highlight that the retail model, featuring by a predominance of the loan portfolio and wide use of deposits as a primary source of financing, is characterized by average levels of profitability and low-performance variability. Differently, Mergaerts and Vennet (2016), analysing market capitalization and bank's risk profile, identified better performance in terms of risk and returns in retail banks. While diversification allows for improved profitability, retail institutions are nevertheless exposed to financial distress and greater exposure to business cycle downturns. This model differs from the typical investing activities BM, equipped with an extensive investment portfolio, and financed mainly through the interbank market (Hryckiewicz and Kozłowski, 2017). This model is characterized by higher levels of economic and financial results volatility compared to other BMs. Following the mistrust in banking institutions during the subprime crisis, the interbank market experienced a sharp contraction in business volumes. Consequently, many wholesale-founded BMs transformed into retail models. In this perspective, De Meo et al. (2016) focused on a dataset of 77 European banking institutions have identified high

levels of profitability in retail banking for the years before the 2007 financial crisis and worse performance during the period of the sovereign debt crisis.

Recently, a further research stream integrated qualitative measures in BM analysis. This orientation represents an alternative to the quantitative procedures generally implemented to highlight analysis dimensions not considered before but explanatory to differentiate between the models (EBA, 2014; Volgarino, 2017). Moreover, integrating this approach with the already consolidated procedures has allowed a hybrid analysis method (Cernov and Urbano 2014). In this perspective, a little explored research body analyze how banks' BMs integrate the environmental policies needed to face climate risk (Toma and Stefanelli, 2022). Based on the primary evidence of possible interconnection between BMs and environmental policies we would broaden the research knowledge; identifying banks' BMs and interconnect it with their ESG practices. The final aim is the assessment of ESG-oriented banking BMs.

2.2 Literature review on ESG practices and banks performance

An extensive literature body has analyzed the implications of environmental, social, and governance (ESG) practices primarily within non–financial firms (Santis et al., 2016; Brogi et al., 2022; Alareeni and Hamdan, 2020) point out that an ESG score improvement can generate a contraction of idiosyncratic risk (Sassen et al., 2016) or lead a risk mitigation effect (Devalle et al., 2017). On profitability perspective, Alareeni and Hamdan (2020) found that environmental and CSR sub-components disclosure are negatively associated with ROA and ROE.

Specifically, basing on CDS spread, Barth et al. (2022) and Palmieri et al. (2022) supports a u-shape relationship between firms' riskiness and ESG scores. In this widely field, some works have focused on each ESG sub-pillars effects on banking industry.

Beside a lot of contributions on environmental practices (Aslan et al., 2021, Gillan et al., 2021), authors such Paltrinieri et al. (2020), Hassan et al. (2021), and Stellner et al. (2015) reinforcing the relevance of social sub-pillar, founding that social score improvements

reinforce a firm's reputation, differently Cash (2018) have attributed to governance score increases the most significant impact on reducing companies' riskiness. Alongside this strand, some authors point out the positive impact of sustainable practices on banking performance, acknowledging the crucial role played by banks to promote a sustainable economic growth. In this perspective, many studies have analyzed the relationship between ESG activities and banking profitability (Wu and Shen, 2013; Buallay, 2018; Menicucci and Paolacci, 2022); for example, Wu and Shen (2013) found that CSR positively associates with return on assets (ROA), return on equity (ROE), net interest income, and non-interest income but negatively impact on non-performing loans. Focusing on Governance sub-pillars, some authors affirm that sustainable banking governance (in terms of ESG Management, Shareholders and CSR scores) can improve the management of bank controversies (Agnese et al., 2022; Galletta et al. 2022, Khan, 2022).

From an holistic point of view, Azmi et al. (2021) found a non-linear relationship between ESG activity and bank value. Their empirical results indicate a positive relationship between ESG activity and both cash flows and efficiency, but also a negative effect on cost of equity and no significantly impact on cost of debt.

In addition, Buallay (2018) empirically demonstrated that: (i) environmental disclosure positively affects the ROA and TQ, (ii) corporate governance disclosure negatively affects the ROA, ROE and TQ, while (iii) CSR disclosure negatively affect all these variables. Menicucci and Paolacci (2022) showed that banks' ESG polices negatively affect operational (ROA, ROE and TQ) and market performance; in particular, environmental improvements (emission and waste reductions) positively impact financial and operating performance. Similarly, Galletta et al. (2023) highlighted that higher ESG scores reduce bank operational risk and impact on bank reputational profiles.

Differently, other authors have focused on whether and how ESG activities affect bank riskiness, found that banks with strong ESG practices tend to be less risky and more resilient to economic shocks. In this field, Chiaramonte et al.(2021), using a sample of European banks over 2005–2017, found that total ESG score, as well as its sub-pillars, reduces bank fragility (measured by Merton's Distance to Default) in time of financial turmoil. From a

risk-taking behavior, the study of Di Tommaso and Thorton (2020), consistently with the "stakeholder" view of ESG activities, shows that high ESG scores are associated with a modest reduction in risk-taking for banks that are high or low risk-takers. A new perspective of analysis is offer by the recent contribution of Citterio and King (2023) that using a sample of 362 US and EU commercial banks, discovered a predictive power of ESG indicators to forecast bank financial distress and thus identify defaulted or healthy banks. Overall, the literature suggests that there is a positive relationship between banks' ESG performance and their riskiness profile. Therefore, banks with strong ESG performance may be perceived as having better governance polices and efficiency risk management systems. These best practices lead to lower risk level and better financial performance.

3. Research design: sample, data, and methodology

To answer our research question, we identify the sample and subsequently gather an initial dataset consisting of yearly observations from 329 banks distributed worldwide from 2007 to 2021 (Table 1). We build a dataset that equally represent banks' total assets, in fact, credit institution belonging to the European Union, United States, and the rest of the world count respectively one third of the sum of the overall total asset gathered in the sample. We use the following selection criteria in order to build our banks dataset from *Bloomberg* and *Thompson Reuters Refinitiv Datastream*[6]:

a) Total capital > 1 billion;

b) Loans to customers > 5 billion;

c) Total liabilities > 10 billion;

d) Total assets > 10 billion.

We also applied a filter in data continuity, and we excluded all banks' yearly observations characterized by clustering variables missing data. As a result, the final dataset contains 49 credit institutions with 571 yearly based bank observations.

[6] 2021 is the reference year for the application of the selection filter

Table 1. Geographical distribution of the sample.

Country	N	%	% TA
JAPAN	81	24,62%	10,13%
ASIA	63	19,15%	7,88%
CHINA	50	15,20%	6,25%
SOUTH AMERICA	46	13,98%	5,75%
EUROPE	37	11,25%	31,58%
USA	18	5,47%	28,32%
AFRICA	17	5,17%	2,13%
UK	11	3,34%	7,21%
CANADA	6	1,82%	0,75%
	329	**100%**	**100,00%**

We found in the current literature the most representative variables able to build a dataset useful for banks' BMs cluster analysis.

The following balance sheet items are commonly used as clustering variables (ECB, 2016; Mergaerts and Vennet, 2016; Ayadi, 2019; Ayadi, 2021) : (i) deposits on total asset to assess the ability of the bank to attract short-term funding sources from customers; (ii) interbank assets to total asset in order to evaluate to what extent the bank uses the interbank market to find sources of financing; (iii) loans to total asset to express the importance of credit granting activities within the BM; (iv) derivative assets to total assets to explicit the usage of derivatives instruments in order to carry out speculative or hedging transactions; (v) asset under management to total asset summarizes the amount of financial resources, managed on behalf of customers, capable of producing commission-related revenues; (vi) risk-weighted assets on total assets provides evidence of the BM's propensity to be predisposed towards capital-intensive investments for the purposes of Basel regulation.

The variables were collected and grouped according to their usefulness for the methodological procedure: (i) dependent variables; (ii) clustering variables; (iii) ESG scores; (iv) capital structure; (v) risk indicators; (vi) other control variables (Appendix 1). We also provide the statistical summary for each variable that compose the dataset (Appendix 2).

The first step of our process is executing an agglomerative hierarchical clustering algorithm, which bases the creation of clusters according to a distance function minimization. This process is called *Ward's minimum variance method*. We implement this algorithm by recalling the clustering function Wards.D2 on R (Ward and Joe, 1963; Batagelj, 1988; Murtagh and Legendre, 2014).

Each bank of our sample has been grouped in a specific cluster according to the values presented in each clustering variable. This involves that the same bank, in different time frames, if they show temporary shocks in charge of clustering variables, could be grouped in different BM clusters, uncorrelated with the previous one.

Furthermore, we looked for the ideal number of clusters (k*) in which we can divide our dataset. More specifically, we execute three different methods to reach the target: the elbow method; the silhouette method; the gap statistic method (Rousseeuw, 1987). Our results suggest that the ideal number of clusters is four (Figure 1). So, coherently with the results obtained in the methods introduced above, we can define four different BMs for our dataset:

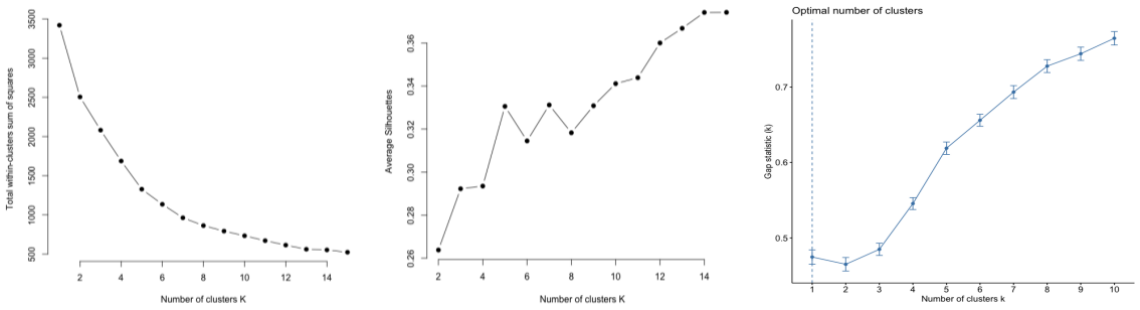
(a) *retail banks* are characterized by the prevalence of loans to customers within the composition of their activities and are mainly financed by the collection of deposits. These institutions are more stakeholder-oriented and they tend to have a positive impact on the real economy while maintaining financial performance and reducing risk for the entire system.

(b) *wholesale banks* use the interbank market as the primary source of financing and they primarily engage in intermediation between other banks, heavily relying on borrowing and lending among themselves. They also tend to execute non-traditional activities such as trading assets.

(c) *banks with diversified assets*, conversely from the retail model, the composition of the assets is more diversified towards non-traditional banking activities such as: stocks, bonds, cash, and financial derivatives. Without an excessive prevalence of one type over another;

(d) *investing activities*, this locution is chosen to incorporate the investment activities carried out by credit institutions on behalf of third parties and their own account. These banks are characterized by an extensive portfolio of securities, the use of derivative instruments, and an income statement focused mainly on commission margins (Appendix 3).

Figure 1. Elbow method (a), Silhouette method (b), Gap statistic method (c).

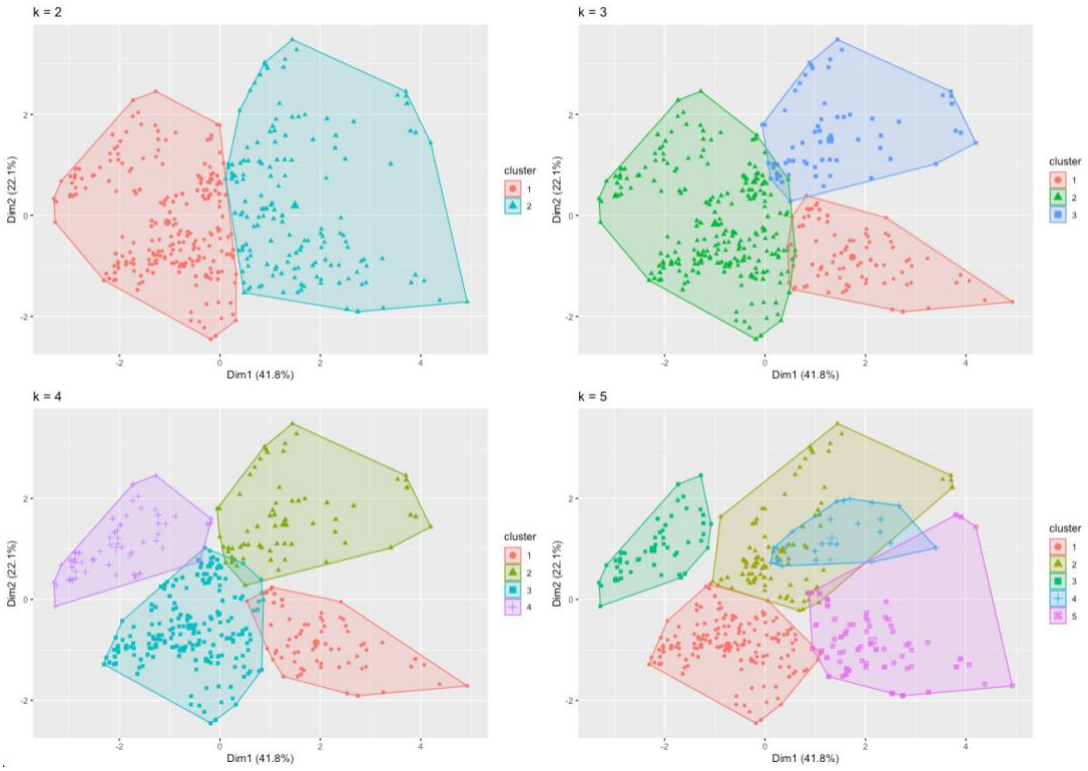


(a) *(b)* *(c)*

The clustering algorithm results are coded as an integer value from one to four, following the number of BMs described above. Finally, we update the dataset and create a set of four dummies to attribute the BM to each bank from the clustering algorithm.

We provide in Figure 2 the results of the clustering procedure implementing the *Wards D2 algorithm*. Coherently with the result of the elbow, the silhouette, and the gap statistic method, the ideal number of clusters is four (k* = 4). The clustering algorithm results are coded as an integer value from one to four, following the number of BMs models described above. We update the dataset and create a set of four dummies to attribute the BM obtained from the clustering algorithm to each bank.

Figure 2. Clustering graphical representation.



In order to reply to the above main research question, we build an econometric model based on pooled OLS, in which the dependent variable is alternatively the probability of default (PD), return on equity (ROE), and return on asset (ROA). Specifically, in the former equation we use Blomberg probability of default (PD), which represents Merton's distance to default measures. This variable is built on market values while z-score (ZSC) is computed as follows (Beck, De Jonghe, & Schepens, 2011; Beck & Laeven, 2006; Boyd & Graham, 1986; Boyd & Runkle, 1993; Garcia-Marco & Roblez-Fernandez, 2008; Hannan & Hanweck, 1988; Hesse & Cihák, 2007; Laeven & Levine, 2006; Maechler, Srobona, & Worrell, 2005; Chiaramonte et al., 2015):

$$Z_{score} = \frac{ROAA + ETA}{\sigma_{ROAA}}$$

With: ROAA as the average return on assets; ETA as equity to total asset ratio; sigma ROAA as the volatility of the average return on assets. The second and third models regress on ROE and ROA respectively.

In our equations, the total ESG score are decomposed according to sub-pillar values: ENV represents the environmental score; SOC is the social score; GOV is the governance score. We have decomposed the total ESG score to represent each sub-pillar's contribution to reducing the probability of default (PD) or any increase in banks' profitability indicators (ROE and ROA). Furthermore, we represented with three dummies if banks belong to a BM rather than another. We omitted the redundant dummy that represents the fourth BM; any contribution in this sense can be observed in the constant. Lastly , consistently with studies examining the relationship between ESG score and performance use as control variables banks' total capital ratio (TCR) in order to express the capital endowment necessary for the bank to cope with any losses due to risk-taking, the natural logarithm of risk-weighted assets (RWA) with the objective to highlight risk-taking policies and capital absorption for the purposes of Basel regulation. We use the following equations for the model:

$$PD_{kit} = \alpha_{it} + ß_1 * PD_{kit-1} + ß_2 * ZSC_{it} + \sum_{i=1}^{4} \theta_i * BM_{it} + \sum_{i=1}^{3} \gamma_i * ESG_{pillar_{it}} + \sum_{i=1}^{3} \lambda_i * Control_{it} + \phi_1 * Bank_{fix_{eff}} + \phi_2 * time_{fix_{eff}} + \epsilon_i$$

$$ROE_{it} = \alpha_{it} + ß_1 * ROE_{it-1} + ß_2 * ZSC_{it} + \sum_{i=1}^{4} \theta_i * BM_{it} + \sum_{i=1}^{3} \gamma_i * ESG_{pillar_{it}} + \sum_{i=1}^{3} \lambda_i * Control_{it} + \phi_1 * Bank_{fix_{eff}} + \phi_2 * time_{fix_{eff}} + \epsilon_i$$

$$ROA_{it} = \alpha_{it} + ß_1 * ROA_{it-1} + ß_2 * ZSC_{it} + \sum_{i=1}^{4} \theta_i * BM_{it} + \sum_{i=1}^{3} \gamma_i * ESG_{pillar_{it}} + \sum_{i=1}^{3} \lambda_i * Control_{it} + \phi_1 * Bank_{fix_{eff}} + \phi_2 * time_{fix_{eff}} + \epsilon_i$$

To strengthen the validity of our findings, we run a set of robustness check. Specifically, we apply for each regression model a fixed effect regression and a random effect model. The multiple Hausman test, confirmed that the pooled OLS model is the most suitable for our

analysis, while the multicollinearity check involved the use of the VIF test. . Finally, in order to prevent endogeneity and heteroskedasticity issues we run a generalized least squared (GLS) regression, adding the one-year lagged dependent variable as regressor.

4. Results

The two steps analysis performed suggests that for investing activities and wholesale banks, the integration of their BMs with ESG score improvements can produce a risk mitigation effect, namely a reduction of default probabilities. Differently, with regards to profitability each BM, interacted with ESG scores, presents a significant contribution to the dependent variables.

We observe that the risk mitigation effect is relevant for environmental and governance sub-pillar score enhancements. These results are coherent with the empirical evidence found in the existing literature (Sassen et al., 2016; Gibson et al., 2021; Aslan et al., 2021).

4.1 – The riskiness analysis

Focusing on banks' BMs, which is the core of our analysis, we observe that investing activities model (BM1) significantly reduce banks' default likelihood starting from the three-year PD with a confidence interval equal to 95%. Moreover, the regression coefficients increase as the PD time horizon expands. Concerning investing activities banks, it is possible to observe that their income statements are more focused on commission margins than interest margins. They primarily generate revenue through activities such as underwriting, issuing, trading securities, and providing financial advisory services. These activities tend to be less risky than those of commercial banks, which take on more traditional forms of risk such as lending money to individuals and businesses. Additionally, investment banks often have a greater focus on managing and hedging risk through the use of financial instruments such as derivatives. Furthermore, investment banks rely on their expertise and reputation rather than on their balance sheet to generate revenue, so they are less exposed to credit and

interest rate risks. These points could explain the mechanism that led to increased banks' creditworthiness if they belong to BM1 (Table 2).

The results on retail banks (BM2) are non-consistent but they present a negative regression coefficient even if they are exposed to a variety of risks in the medium-long term, including credit risk, interest rate risk, and liquidity risk. In order to explain the sign, we recall the different measures retail banks implement to reduce credit risk, such as careful lending practices, loan portfolio diversification, setting appropriate loan terms and conditions, effective loan loss provisioning, using credit risk mitigation techniques.

Wholesale business model (BM3) still not present significant regression coefficients. This business model may be considered less risky as the bank is less exposed to consumer credit risk, and instead focuses on providing services such as corporate lending, trade financing, and investment banking. Additionally, wholesale banks often have higher capital ratios and more diversified sources of revenue, which can help to mitigate risk.

Diversified assets banks (BM4) regression coefficient can be observed as risk reduction contribution in the constant term. A bank with a diversified asset business model can be considered less risky as it spreads its investments and lending activities across a variety of sectors, industries, and geographic regions. However, if the bank has a diversified portfolio with loans in multiple industries, the impact of a downturn in one industry may be less severe. Diversification of assets also allows banks to spread out their risk across different regions, this way a crisis in one region would not have a severe impact on the bank.

As expected, environmental, social, and governance pillars tend to show a negatively regression coefficient producing a contraction of default probabilities. The interpretation of this result can be resumed as a tendency of ESG individual pillars to reduce banks' likelihood of default.

Moreover, we observe that the magnitude of reduction of banks' probabilities of default increases as the time horizon expands. For every environmental score marginal improvement, the probabilities of default at five years decrease by 0.015 with a 99% confidence interval. On the other hand, the same increase in environmental pillars negatively impacts one bank's one-year probability of default by -0.009%. These results

suggest a time gap exists between environmental score improvements and the incorporation of news into market quotations. In fact, reducing the probability of default produces more significant effects on particularly long-time horizons. Banks with high environmental scores may be considered less risky as they tend to have better environmental practices and are more likely to be prepared for the potential risks associated with climate change and other environmental challenges.

Similarly, the government sub-pillar presents a confidence interval of 95% and it is possible to observe an increase of the risk mitigation effect as time horizon expands. Banks with high governance scores may be considered less risky as they tend to have better governance practices and are more likely to have sustainable and responsible business practices. Governance factors, such as a bank's commitment to transparent and ethical business practices, can also reduce the bank's risk by reducing its exposure to operational and regulatory risks.

Conversely, social score does not present any statistical relevance, in opposition to previous studies, which found a risk mitigation effect as a consequence of social sub-pillar improvements (Stellner et al., 2015; Bhattacharya and Sharma, 2018; Cash, 2018; Kiesel and Lücke, 2019; Kim and Li, 2021).

The control variable total capital ratio (TCR) shows a significance of 90% for one-year probability of default, and for each percentage increase in TCR, there is correspondent PD reduction equal to 0.014%. Both the regression coefficient magnitude and confidence interval growths as the time horizon expands. The TCR coefficient, required for regulatory purposes by Basel III, seems to produce a substantial risk mitigation effect over medium-long term time horizons. At the same time, risk-weighted assets (RWA) and Z-score do not produce any reduction of banks' PD.

Table 2. Regression results (GLS model) for riskiness

	PD1	**PD3**	**PD5**
Constant	1.544 ***	2.118 ***	2.533 ***
	(0.314)	(0.396)	(0.441)
PD1L	0.329 ***		
	(0.039)		
PD3L		0.323 ***	
		(0.037)	
PD5L			0.308 ***
			(0.036)
ZSC	-0.001	-0.001	-0.002
	(0.002)	(0.003)	(0.003)
BM1	-0.124	-0.217**	-0.287**
	(0.082)	(0.103)	(0.115)
BM2	-0.006	-0.082	-0.149
	(0.073)	(0.092)	(0.103)
BM3	- 0.011	-0.099	-0.196
	(0.085)	(0.107)	(0.120)
ENV	-0.009 ***	-0.013 ***	-0.015 ***
	(0.003)	(0.004)	(0.005)
SOC	0.0003	0.0001	-0.0001
	(0.002)	(0.003)	(0.003)
GOV	-0.005 **	-0.007 **	-0.008 **
	(0.002)	(0.003)	(0.003)
TCR	-0.014 *	-0.020 **	-0.026 **
	(0.008)	(0.010)	(0.011)
RWA	-0.024	-0.017	-0.006
	(0.027)	(0.034)	(0.038)
Bank fixed effect	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes
Observations	534	534	534
F-Statistic	13.244 ***	14.432 ***	15.209 ***
p-value on df 10; 523	0.000	0.000	0.000

* p<0.1; ** p < 0.05; ***p < 0.01

In order to capture the joint effect of ESG performance and banks' business model on riskiness, we propose in Table 3 the results of a GLS regression model that consider any possible variables interaction. We decide to multiply each BM dummy for the overall ESG score in order to prevent multicollinearity issues.

As result we observe for investing activities business model (BM1) * ESG a marginal risk mitigation effect equal to -0.009 for the one-year PD and this coefficient growths as time horizon expands with a confidence interval equal to 99%. ESG performance seems to be relevant for banks that invest for their own and for their customers. In this sense, banks' public perception and reputation play a role in credit institution market values. Investment banks can reduce their default probability after an increase in their Environmental, Social, and Governance (ESG) score because investing activities banks with higher ESG scores tend to have better financial performance and are less likely to experience financial distress. Additionally, companies with higher ESG scores may be viewed as being more responsible and sustainable, which can increase investor confidence and reduce the risk of default. This can be due to the fact that companies with higher ESG scores tend to have better risk management practices, more transparent operations, and stronger relationships with stakeholders, which can all contribute to their financial stability. As a consequence, market-based probabilities of default can benefit from ESG performance improvements (Mamatzakis & Bermpei, 2015).

With a 95% confidence interval wholesale business model (BM3) can reduce default probabilities with regression coefficients that follow the same time-dependent growth observed for BM1. Wholesale banks with higher ESG scores may have better risk management practices, more transparent operations, and stronger relationships with stakeholders, which can all contribute to their financial stability. They may also benefit from the fact that credit institutions with higher ESG scores may be viewed as more attractive borrowers by investors, which can make it easier for them to raise funds and reduce the risk of default.

Conversely, retail business model (BM2) is not affected by ESG performance in mitigating default risk. Retail banks may not see a reduction in their default probability due

because the relationship between ESG performance and default risk may be more complex for retail banks than for other types of banks. Retail banks may have a more diverse set of customers and loan portfolio, which makes it more difficult to generalize about the relationship between ESG performance and default risk. Additionally, retail banks may not have the same level of visibility and access to information about the ESG performance of their borrowers as investment or wholesale banks, which could make it more difficult to assess the relationship between ESG performance and default risk. Also, retail banks may not have the same incentives or resources to focus on ESG performance as other types of banks, which could limit their ability to improve their ESG score.

Table 3. Regression results (GLS model) for riskiness with interactions

	PD1	PD3	PD5
Constant	1.451 ***	1.871 ***	2.207 ***
	(0.287)	(0.362)	(0.403)
PD1L	0.332 ***		
	(0.039)		
PD3L		0.324 ***	
		(0.037)	
PD5L			0.305 ***
			(0.036)
ZSC	-0.003	-0.004	-0.005
	(0.002)	(0.003)	(0.003)
BM1 * ESG	-0.009 ***	-0.012 ***	-0.015 ***
	(0.003)	(0.004)	(0.005)
BM2 * ESG	0.0004	0.0005	-0.0006
	(0.003)	(0.004)	(0.004)
BM3 * ESG	-0.004 **	-0.005 **	-0.006 **
	(0.002)	(0.002)	(0.003)
TCR	-0.013 *	-0.018 **	-0.023 **
	(0.008)	(0.010)	(0.011)
RWA	-0.045	-0.048	-0.046
	(0.023)	(0.029)	(0.032)
Observations	534	534	534
F-Statistic	15.805 ***	17.157 ***	17.965 ***

p-value on df 7; 526	0.000	0.000	0.000

* p<0.1; ** p < 0.05; ***p < 0.01

4.2 The profitability analysis

Concerning investing activities banks (BM1), it is possible to observe a ROA reduction of 0.18% points with a 99% confidence interval. At the same time, ROE seems to be not affected by BM1**.** In fact, investment banks tend to have lower levels of Return on Assets (ROA) compared to the other BMs. They have a higher level of risk in their operations due to the nature of their business, which involves underwriting securities, market making, and providing other financial services that are more complex and riskier than those offered by retail and wholesale banks. This can result in higher volatility in earnings and lower overall returns. Furthermore, they typically have higher levels of fixed costs such as compensation, rent, and regulatory compliance costs, which can shrink profitability. Investing activities banks tend to have a business model focused on high-margin activities such as underwriting, mergers and acquisitions, and trading. These activities require large amounts of capital and expertise, which can drive up costs and lower returns. Additionally, these banks may have a more limited customer base and revenue stream compared to retail and wholesale banks. Finally, investing activities banks may be more reliant on a smaller number of high-profit activities and customers, which can make their earnings more volatile and lower overall returns (Table 4).

Similarly, the retail banks (BM2) do not affect ROE, while the effect on ROA is equal to -0.578 points with a statistical significance of 99%. Retail banks tend to have lower levels of Return on Assets (ROA) compared to other bank business models such as investment and wholesale banks because retail banks typically have a more diversified set of customers and loan portfolio, which results in lower returns on assets. Retail banks offer a wide range of products and services to a large number of customers, and their revenue is spread over a broader base. This helps to mitigate risk, but it also means that the returns on assets will be lower compared to investment and wholesale banks. Furthermore, retail banks have to

comply with a large number of regulations, which can increase their cost of operations. They also have to maintain more physical branches to serve their customers, which can increase their overhead costs. These expenses can lower their return on assets. Moreover, they typically have a more conservative approach to lending, which can also result in lower returns on assets. They are more likely to lend to customers with lower credit scores and to make smaller loans with lower interest rates. This can help to mitigate risk, but it also means that the returns on assets will be lower compared to investment and wholesale banks.

A more remarkable reduction in profitability can be observed in charge of wholesale banks (BM 3) with a confidence interval of 99%. This result is coherent with the activity carried out by this kind of institutions. Their primary focus is on providing services to other financial institutions and corporations, rather than retail customers. These services include lending, underwriting, and trading activities. These activities tend to be less profitable and have higher operating costs than those of retail banks, leading to lower ROA. Additionally, wholesale banks tend to have less diversified revenue streams and may be more exposed to market risks, which can also contribute to lower ROA.

Banks with diversified asset (BM4) presents a positive contribution to profitability and a confidence interval of 99%. Their asset diversification can reduce the overall risk of the bank's portfolio. When a bank's assets are diversified, it means that the bank has invested in a variety of different types of assets, such as loans to different types of borrowers, different types of securities, and different geographic regions. This involve that the bank's performance is less dependent on the performance of any one particular type of asset. Additionally, diversification can also provide a bank with multiple sources of revenue, which can help to stabilize the bank's income and cash flow. When a bank has a diverse set of assets, it is able to generate revenue from a variety of different sources, which can help to offset any losses that may occur in one particular area.

Regarding return on equity (ROE), a unit increase in the environmental score leads to a higher return on equity of 0.101 points. The confidence interval is equal to 99%. This result is remarkable because, for our dataset of banks, an improvement in environmental score produces a slight improvement in profitability. Banks with environmental score

enhancements tend to have higher return on equity (ROE) due to several reasons such as being viewed favorably by investors, better management of environmental and sustainability risks, ability to raise capital at favorable rates, potential benefits from increased demand for environmentally friendly products and services, and improved brand loyalty and reputation. Concerning return on assets (ROA), there is no statistical relevance between asset profitability and environmental pillar enhancements. In fact, banks with strong environmental and sustainability practices may be viewed favorably by investors, leading to higher ROE, and may also have lower operating costs due to lower risk, which can also increase ROE. This kind of banks may also be viewed as socially responsible and trustworthy, leading to increased brand loyalty and reputation, and can also be seen as lower risk by investors, leading to higher ROE. However, these factors may not necessarily have a direct impact on the bank's ROA.

Meanwhile, the governance sub-pillar can increase both ROE and ROA with a statistical significance of 99%. The contribution in terms of increases in ROE is equal to 0.046 points for each marginal increase in governance pillar performance, while the ROA counterpart is 0.003. To explore the impact of this evidence, we recall that the governance sub-pillar deals with the quality of management, implementation of corporate social responsibility (CSR) strategies, shareholders' rights, and hostile takeovers. All these areas can considerably impact banks' profitability and performance. Banks with good corporate governance practices can ensure that the credit institution is well-managed and efficient, which can lead to higher ROA. These practices can also mitigate risks and prevent fraud, which can improve ROE. Banks with good governance are viewed as trustworthy and responsible, which can lead to higher valuations, increase the amount of capital it can raise, and improve their ability to secure favorable funding terms. Additionally, good governance practices can attract and retain top talent, leading to higher productivity and better decision making, which can also improve ROE and ROA. Finally, good governance practices can help banks to be compliant with regulations and laws, avoiding penalties and fines, which can also improve ROE and ROA. Overall, good governance practices contribute to the overall performance and profitability.

Coherently with riskiness results, a marginal increase in the social sub-pillar do not improve banks' profitability. The positive spillover generated by taking into consideration social issues like workforce conditions, respect for human rights, contribution to the community, and product responsibility will increase banks' reputation, but we cannot observe any relevant impact on banks' profitability. More specifically social responsibility can be an important consideration for customers, employees, and the general public, but it may not have a direct impact on the bank's financial performance. Banks may have difficulty measuring the financial impact of their social initiatives, making it difficult to quantify the impact on ROE and ROA. Social initiatives may require significant investments and resources, which can be costly and may not have a direct impact on the bank's financial performance. Furthermore, social initiatives may not be directly related to the bank's core operations and may not be able to generate significant returns. Banks may need to balance the benefits of social initiatives with the costs and resources required to implement them and the potential impact on financial performance.

Moreover, we can affirm that increases in banks' total capital ratio (TCR) can increase both ROE and ROA. More capital endowments seem to be able to improve banks' performance. The statistical confidence is equal to 99%. Lastly, a marginal increase in RWA do not affects bank profitability. In addition, Z-score marginal improvements still are unable to modify ROE and ROA.

Table 4. Regression results (GLS model) for profitability

	ROA	**ROE**
Constant	0.587 ***	3.863
	(0.197)	(3.118)
ROAL	0.425 ***	
	(0.035)	
ROEL		0.454 ***
		(0.036)
ZSC	-0.001	-0.027
	(0.002)	(0.024)
BM1	-0.180***	0.873

	(0.052)	(0.819)
BM2	-0.366 ***	-1.071
	(0.051)	(0.736)
BM3	-0.547 ***	-3.627 ***
	(0.061)	(0.879)
ENV	0.002	0.101 ***
	(0.002)	(0.033)
SOC	-0.001	0.00001
	(0.002)	(0.024)
GOV	0.003 **	0.046 *
	(0.002)	(0.024)
TCR	0.016 ***	0.250 ***
	(0.005)	(0.083)
RWA	-0.026	-0.345
	(0.017)	(0.273)
Bank fixed effect	Yes	Yes
Time fixed effect	Yes	Yes
Observations	534	534
F-Statistic	55.965 ***	39.213 ***
p-value on df 10; 523	0.000	0.000

* p<0.1; ** p < 0.05; ***p < 0.01

To verify whether the joint effect of ESG performance and business model specification we interact these two variables in order to analyze the effect on banks' profitability proxies. The combined effect of ESG and investing activities BM is positive and statically relevant both for return on asset and return on equity. Banks that adopt BM1 show a noteworthy increase in profitability when they improve ESG performance. ESG considerations are becoming increasingly important for investors and clients, and investment banks that are seen as strong in ESG factors may be viewed more favorably by these stakeholders. This can lead to an increase in ROE and ROA by attracting more investment and business opportunities. This institution with strong ESG practices may be better able to identify and manage ESG risks in their investment portfolios, which can help to reduce the overall risk of the bank's portfolio and improve its ROE and ROA. ESG-related products and services may benefit from increased demand for these products and services as more investors and

clients are becoming conscious of ESG factors, which can lead to higher ROE and ROA. ESG practices may contribute to create a more trustworthy and socially responsible perception for its customers, employees, and the general public. This can lead to increased brand loyalty and reputation, which can also increase ROE and ROA (Table 5).

The same conclusions could be obtained for retail business model (BM2) with a confidence interval of 99% for ROA and 90% for ROE. We observe a similar contribution to ROA between the ESG interaction with investing activities and retail business model. With regards to ROE, the joint contribution of ESG and BM2 present a lower level for the regression coefficient. Overall retail banks that improve their ESG performance can expect to see an increase in ROE and ROA due to a reduction in risks, an increase in reputation and brand loyalty, and access to more favorable funding sources. Additionally, they are likely to benefit from increased demand for environmentally friendly products and services.

Conversely, wholesale banks could observe a return on asset reduction following ESG score enhancements with a relevance of 95%. Wholesale banks (BM3) may have to invest more resources and funds in order to meet higher ESG standards, which can lead to higher operating costs and lower ROA. They may face increased regulatory scrutiny and fines for non-compliance with ESG standards, which can also lead to lower ROA. There is no remarkable effect on the return on equity.

Table 5. Regression results (GLS model) for profitability with interactions

	ROA	ROE
Constant	0.401 **	4.807 *
	(0.181)	(2.850)
ROAL	0.439 ***	
	(0.034)	
ROEL		0.472 ***
		(0.035)
ZSC	-0.002	-0.010
	(0.002)	(0.003)
BM1 * ESG	0.004 ***	0.051 **
	(0.001)	(0.020)

BM2 * ESG	0.005 ***	0.023 *
	(0.001)	(0.013)
BM3 * ESG	-0.005 **	-0.055
	(0.002)	(0.034)
TCR	0.016 ***	0.255 ***
	(0.005)	(0.082)
RWA	-0.025	-0.345
	(0.015)	(0.230)
Observations	534	534
F-Statistic	68.403 ***	47.830 ***
p-value on df 7; 526	0.000	0.000

* p<0.1; ** p < 0.05; ***p < 0.01

4.3 Robustness check

To verify if the pooled OLS model is the best model to analyze our dataset, we conducted robustness tests by performing regressions with fixed effects (FE) as from the Hausman test we should prefer a fixed effect model rather than a random effect model. This test aims to verify if the results obtained are robust and consistent, even if different regression models are involved in the analysis.

In term of risk mitigation effect (PD), it can be observed that the environmental score is statistically significant in each model for any default probability considered with a 99% confidence interval. More specifically, the social score still not present any statistical relevance, while governance assumes a significance of 95% both for GLS and fixed effect model in all the three extensions of the default likelihood.

The contribution of the BMs in mitigating credit institutions' default probabilities is still inconsistent even with the fixed effects model. The same conclusion can be obtained for the z-score in both models. With regard to the control variables, the total capital ratio assumes less significance with the fixed effects model for PD long time extensions. Conversely, risk-weighted assets are significant in the fixed effect model with a confidence interval of 99% in, each time horizon (Table 6).

Table 6. GLS and fixed effect robustness test for the default probabilities.

	PD1		PD3		PD5	
	GLS	**Fixed**	**GLS**	**Fixed**	**GLS**	**Fixed**
Constant	1.544 ***	1.831 ***	2.118 ***	1.974 ***	2.533 ***	2.254 ***
	(0.314)	(0.352)	(0.396)	(0.403)	(0.441)	(0.471)
PD1L	0.329 ***	-0.008				
	(0.039)	(0.043)				
PD3L			0.323 ***	0.003		
			(0.037)	(0.041)		
PD5L					0.308 ***	0.005
					(0.036)	(0.040)
ZSC	-0.001	-0.0003	-0.001	-0.001	-0.002	-0.001
	(0.002)	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)
ENV	-0.009 ***	-0.013 ***	-0.013 ***	-0.017 **	-0.015 ***	-0.018 ***
	(0.003)	(0.005)	(0.004)	(0.006)	(0.005)	(0.721)
SOC	0.0003	0.001	0.0001	0.002	-0.0001	0.002
	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)	(0.005)
GOV	-0.005 **	-0.008 **	-0.007 **	0.010 **	-0.008 **	0.010 **
	(0.002)	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)
BM1	-0.124	0.386	-0.217**	0.511	-0.287**	0.578
	(0.082)	(0.258)	(0.103)	(0.325)	(0.115)	(0.360)
BM2	-0.006	0.216	-0.082	0.278	-0.149	0.309
	(0.073)	(0.306)	(0.092)	(0.386)	(0.103)	(0.428)
BM3	0.01	0.247	-0.099	0.314	-0.196	0.347
	(0.085)	(0.383)	(0.107)	(0.482)	(0.120)	(0.536)
TCR	-0.014 *	0.028 *	-0.020 **	0.037 *	-0.026 **	0.040 *
	(0.008)	(0.017)	(0.010)	(0.021)	(0.011)	(0.023)
RWA	-0.024	0.749 ***	-0.017	0.944 ***	-0.006	1.055 ***
	(0.027)	(0.207)	(0.034)	(0.262)	(0.038)	(0.291)
Bank fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	534	534	534	534	534	534
F-Statistic	13.244 ***	3.662 ***	14.432 ***	3.778 ***	15.209 ***	3.702
p-value on df 10; 523	0.000	0.000	0.000	0.000	0.000	0.000

* p<0.1; ** p < 0.05; ***p < 0.01

About the regressions run on profitability ratios, it can be observed that in opposition to the results obtained in the GLS model, for the fixed effect model, the governance performance is not statistically relevant. These results are replicated for the social score while environmental sub-pillar remain significant for the return on equity in both models.

The results regarding the BM's impact on credit institutions' profitability are contradictory. As far as profitability is concerned, there is no convergence between the GLS model and the fixed effects model.

Regarding control variables, the total capital ratio is significant at 99% in both models considered. The risk-weighted assets remain not significant even in the fixed effect model. For this model the Z-score assumes a 95% relevance assessing return on asset performance (Table 7).

Table 7. GLS and fixed effect robustness test for ROE and ROA.

	ROA		ROE	
	GLS	Fixed	GLS	Fixed
Constant	0.587 ***	0.472 ***	3.863	3.453
	(0.197)	(0.184)	(3.118)	(3.027)
ROAL	0.425 ***	0.117 ***		
	(0.035)	(0.039)		
ROEL			0.454 ***	0.109 ***
			(0.036)	(0.040)
ZSC	-0.001	0.005 **	-0.027	0.042
	(0.002)	(0.002)	(0.024)	(0.037)
ENV	0.002	- 0.350	0.101 ***	0.141 ***
	(0.002)	(0.325)	(0.033)	(0.050)
SOC	-0.001	-0.001	0.00001	- 0.015
	(0.002)	(0.002)	(0.024)	(0.033)
GOV	0.003 **	- 0.000	0.046 *	0.019

		(0.002)	(0.002)	(0.024)	(0.035)
	BM1	-0.180***	- 0.031	0.873	0.117
		(0.052)	(0.163)	(0.819)	(2.514)
	BM2	-0.366 ***	- 0.049	-1.071	0.292
		(0.051)	(0.193)	(0.736)	(2.984)
				-3.627	
	BM3	-0.547 ***	- 0.119	***	-0.466
		(0.061)	(0.242)	(0.879)	(3.737)
			0.035	0.250	0.653
	TCR	0.016 ***	***	***	***
		(0.005)	(0.010)	(0.083)	(0.158)
		-0.026	- 0.040	-0.345	- 0.801
	RWA	(0.017)	(0.128)	(0.273)	(1.969)
	Bank fixed effect	Yes	Yes	Yes	Yes
	Time fixed effect	Yes	Yes	Yes	Yes
	Observations	534	534	534	534
		55.965	4.445	39.213	4.582
	F-Statistic	***	***	***	***
	p-value on df 10;				
523		0.000	0.000	0.000	0.000

* p<0.1; ** p < 0.05; ***p < 0.01

From the variance inflation factor (VIF) summary table it is possible to observe that for all variables used in regression models, the VIF is below the critical threshold of 5. Therefore, the presence of multicollinearity between the variables is excluded (Table 6).

Table 8. Variance Inflation Factor (VIF) table.

ZSC	ENV	SOC	GOV	BM1	BM2	BM3	TCR	RWA
1.29	1.73	1.67	1.35	2.28	2.89	2.06	1.26	2.08

As robustness test we run a pooled OLS regression on all the dependent variables that express both riskiness and profitability performance with respect to clustering variables. In

this way it is possible to estimate if the business model we obtained represents a good regressor for our dependent variables (Table 9).

Interest margin on total assets, loan on total assets and assets under management on total assets presents a confidence interval of 99% both for riskiness and profitability proxies. A similar same pattern is followed by derivatives on total assets with the exception for the one-year probability of default that is significant with a 95% confidence interval. Deposits on total assets represent a significative regressor only for profitability measures (ROA and ROE), while risk weighted assets on total assets is relevant for each profitability and riskiness variable with exception to PD1.

We can conclude that the clustering variables, resumed in the business model dummies, represent a significative regressor for our regression models.

Table 9. Regression of dependent variables according to cluster variables

	PD1	**PD3**	**PD5**	**ROA**	**ROE**
Constant	1.781***	2.443 ***	2.837 ***	-0.291 *	-1.947
	(0.238)	(0.302)	(0.337)	(0.155)	(2.426)
DEP_TA	-0.003	-0.004	-0.003	0.006 ***	0.121 ***
	(0.002)	(0.003)	(0.003)	(0.001)	(0.021)
INT_TA	-0.019***	-0.024***	-0.026***	0.010***	0.221***
	(0.005)	(0.006)	(0.007)	(0.003)	(0.050)
DER_TA	-0.013**	-0.018***	-0.021***	-0.017***	-0.280***
	(0.005)	(0.007)	(0.007)	(0.003)	(0.054)
LOAN_TA	-0.011***	-0.016***	-0.018***	0.004**	0.115***
	(0.003)	(0.004)	(0.004)	(0.002)	(0.030)
AUM_TA	-0.002***	-0.002***	-0.002***	0.003***	0.032***
	(0.0005)	(0.001)	(0.001)	(0.0003)	(0.005)
RWA_TA	0.002	0.005**	0.007***	-0.095***	-0.095***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.017)
Observations	534	534	534	534	534
F-Statistic	4.553 ***	5.359 ***	6.217 ***	58.957 ***	37.855 ***
p-value on df 6; 527	0.000	0.000	0.000	0.000	0.000

5. Conclusion, limits, and implications

The study aimed to explore banks' ESG-oriented BMs can improve banks' performance. Specifically, we investigate a possible mitigation of credit institutions' default probabilities and an increase of return on equity (ROE) and return on asset (ROA). To achieve this goal, we perform a GLS model to 534 yearly-based worldwide bank observations for the period 2007 – 2021.

The first contribution of this paper is the differently BM's impact on banks' default probability considering multiple time horizons. More specifically, we found that investing activities (BM1) and wholesale (BM3) banks' BMs exhibit a consistent risk mitigation effect triggered by ESG performance enhancements. Coherently with the reference literature (Cash, 2018; Chiaramonte et al. 2021), banks' default probability is mitigated due to improvements in environmental and governance scores. Unlike the findings of Paltrinieri et al. (2020) and Hassan et al. (2021) we found that a better social sub-pillar performance does not produce any meaningful PD reduction for credit institutions. This result remarks that European banking system is more oriented towards stockholders' interests rather than stakeholders' ones. As a consequence, market-based default probabilities that represent a proxy of banks' idiosyncratic risk are not affected by social pillar in any time horizon considered in the present work.

A further contribution is identifying a differentiated impact on banks' profitability ratios. More in detail, it is observed that the interaction among ESG performance and BM contribute to increase banks' ROA for investing activities and retail models, differently it produces a contraction for wholesale banks. On the stockholder side, ROE ratio benefits from ESG performance improvements for retail and investing activities banks.

We are aware of the limits of our research. Firstly, from a methodological standpoint, the BM analysis carried out with cluster analysis is particularly sensitive to variations in clustering variables. Secondly, the present study is focused on the direct effect of ESG scores in banking institutions (Co2 emissions). On the other hand, we miss the indirect effects, such as improving the environmental profile of the credit portfolio, that is difficult to monitor.

In term of implications, our results suggest that: (i) policy maker should promote, through incentives or regulations, the ESG integration into banks' business model to spread sustainable business practices and reduce idiosyncratic risk; (ii) banks supervisory authorities are interest in increasing transparency and disclosure requirements for banks with regards to ESG practices and performance, for better accountability and informed decision making by stakeholders; (iii) legislator and academics should promote education and awareness among stakeholders, including bank customers and investors, about the importance of ESG factors in financial performance and risk management; (iv) international organization have to encourage the collaboration and partnerships between banks, regulators, and other relevant organizations to advance sustainable finance and promote responsible business practices.

We suggest further investigation on the relationship between banks' ESG-oriented BMs and credit institutions' performance to contribute to the policy debate. Specifically, scholars could investigate how second-level ESG sub-indicators impact the banks' default probability and profitability. Furthermore, it could be analyzed whether the risk-mitigation effect in the banking sector has regional and territorial differences, as noted by the reference literature for non-financial enterprises (Yang & Yulianto, 2021).

Therefore, our research provides new evidence to support the effectiveness of the integration of ESG performance in the banks' BMs analysis and outline the impacts in term of performance for any ESG score improvement according to the business model adopted by the credit institution.

6. Acknowledgements

We thank conference participation at the International Conference of Sustainability, Environment, and Social Transition in Economics and Finance (ENS University Paris-Saclay), and in particular, Prof. Broccardo E. and Ruza C., and discussants: Chanaka G. All remaining errors are our own.

7. Reference

Altunbas Y., Manganelli S., Marques-Ibanez D., (2011), "Bank risk during the financial crisis: do business models matter?", ECB Working Paper Series, No. 1394, p.14.

Amel D.F., Rhoades S.A., (1988), "Strategic groups in banking", The Review of Economics and Statistics, Vol. 70, No. 4, pp. 685–689. https://doi.org/10.2307/1935834

Aslan, A., Poppe, L., Posch, P. (2021), "Are Sustainable Companies More Likely to Default? Evidence from the Dynamics between Credit and ESG Ratings", Sustainability, 13, 8568. https://doi.org/10.3390/su13158568

Avetisyan, E., Hockerts, K., (2017), "The Consolidation of the ESG Rating Industry as an Enactment of Institutional Retrogression", Business Strategy and the Environment, 26, pp. 316-330. https://doi.org/10.1002/bse.1919

Ayadi R.E., Bongini P., Casu B., Cucinelli D. (2021), "Bank Business Model Migrations in Europe: Determinants and Effects", British Journal of Management, pp. 17-18. https://doi.org/10.1111/1467-8551.12437

Ayadi R.E., De Groen W.P., (2014), "Banking business models monitor 2014: Europe", available at: https://www.ceps.eu/ceps-publications/banking-business-models-monitor-2014-europe

Ayadi R.E., De Groen W.P., Sassi I., Mathlouthi W., Rey H., Aubry O., (2016a), "Banking business models monitor 2015: Europe", available at: https://www.ceps.eu/ceps-publications/banking-business-models-monitor-2015-europe

Ayadi R.E., Ferri G., Pesic V., (2016b), "Regulatory arbitrage in EU banking: do business models matter?", International Research Center on Cooperative Finance (IRCCF) Working Paper, pp.12-13. http://dx.doi.org/10.2139/ssrn.2829027

Ayadi R.E., Ferri G., Pesic V., (2019), "Does Business Model Instability Imperil Banks' Soundness? Evidence from Europe", Bancaria, No. 7/8, p. 28.

Ayadi, R., De Groen W., Sassi, I., Mathlouthi, W., Rey, H., Aubry, O. (2015). Banking business models monitor 2015. Alphonse and Dorimène Desjardins International Institute for Coopeatives & Interna- tional Research Centre on Cooperative Finance.

Ayadi, R., De Groen, W. (2014). Banking business models monitor 2014. Centre for European Policy Stud- ies and International Observatory on Financial Services Cooperatives.

Bank of International Settlement (BIS). (2022), "Supervisory practices for assessing the sustainability of banks' business models", April 2022.

Barth, F., Hübel, B., Scholz, H., (2022), "ESG and corporate credit spreads", Journal of risk finance, pp. 2-4. https://doi.org/10.1108/JRF-03-2021-0045

Batagelj V., (1988), "Generalized Ward and Related Clustering Problems", Classification and Related Methods of Data Analysis, Working Paper, pp. 67-74. http://vlado.fmf.uni-lj.si/pub/preprint/ward.pdf

Beck, T., De Jonghe, O., Schepens, G., (2011), "Bank completion and stability: Cross-country heterogeneity. European banking center discussion paper 19. Tilburg University.

Beck, T., Laeven, L., (2006), "Resolution of failed banks by deposit insurers: Cross-country evidence". World Bank policy research working paper, 3920.

Berg, F., Koelbel, J.F., Rigobon, R., (2019), "Aggregate Confusion: The divergence of ESG ratings", MIT Sloan School Working Paper, 2019, 5822, pp. 28-33. http://dx.doi.org/10.2139/ssrn.3438533

Bhattacharya, S., Sharma, D., (2018), "Do environment, social and governance performance impact credit ratings: a study from India", International Journal of Ethics and Systems, 35, pp. 479-481. https://doi.org/10.1108/IJOES-09-2018-0130

Boyd, J. H., Graham, S. L., (1986). "Risk, regulation, and bank holding company expansion into nonbanking", Quarterly Review — Federal Reserve Bank of Minneapolis, p. 10.

Boyd, J., Runkle, D. E., (1993), "Size and performance of banking firms. Journal of Monetary Economics", 31, pp. 47–67.

Breuer, H., Fichter, K., Lüdeke-Freund, F., Tiemann, I., (2018), "Sustainability-Oriented Business Model Development: Principles, Criteria, and Tools", International Journal of Entrepreneurial Venturing, 10, pp. 256-286. http://dx.doi.org/10.1504/IJEV.2018.10013801

Cash, D., (2018), "Can credit rating agencies play a greater role in corporate governance disclosure?", Corporate Governance, 18, pp. 960-964. https://doi.org/10.1108/CG-04-2018-0150

Cernov M., Urbano T., (2014), "Identification of EU bank business models: a novel approach to classifying banks in the EU regulatory framework", EBA staff paper series, No. 2, pp. 37–38, available at: https://www.eba.europa.eu/

Christensen, D.M., Serafeim G., Sikochi A., (2021), "Why is Corporate Virtue in the Eye of the Beholder? The Case of ESG Ratings", The Accounting Review, pp. 34-35. https://doi.org/10.2308/TAR-2019-0506

De Meo E., De Nicola A., Lusignani G., Zicchino L., (2016), "European banks in the XXI century: Are their business models sustainable"?, EBA working paper. Available at: https://www.eba.europa.eu/

De Santis, A., Di Marzo, G., Fasano, D., Marlino, M., Nigro, B., (2020), "Pricing risk adjusted: il ruolo dei parametri ESG", PE Working Paper. 2020, pp. 40-45. Available at: https://shorturl.at/lpCY0

Devalle, A., Fiandrino, S., Cantino, V., (2017), "The Linkage between ESG Performance and Credit Ratings: A Firm-Level Perspective Analysis", International Journal of Business and Management , 12, pp. 53-65.

EBA (2014), "Guidelines on Common Procedures and Methodologies for the Supervisory Review and Evaluation Process (SREP)", EBA/GL/2014/13, available at: https://www.eba.europa.eu.

EBA (2018), "Speech at the Deutsche Bundesbank Conference - Bank business models - Structural changes and their systemic implications", p.7, available at: https://www.eba.europa.eu

EBA (2020), "Guidelines on loan origination and monitoring", Final Report, EBA/GL/2020/06.

EBA (2021), "EBA Discussion Paper on Management and supervision of ESG risks for credit institutions and investment firms. Explanatory note on the EBA comprehensive approach to loan origination", EBA.

ECB, (2010), "Beyond ROE – how to measure Bank performance", September, www.ecb.europa.eu/pub

ECB, (2016), "Recent trends in euro area banks' business models and implication for banking sector stability", Financial Stability Review, No. 7-8, Francoforte.

ECB, (2018), "Guidelines on common procedures and methodologies for the supervisory review and evaluation process (SREP) and supervisory stress testing", Francoforte.

Ernst&Young, (2019), How ESG creates long-term value: Sustainability's new frontier, pp. 3-5.

European Central Bank (ECB). (2022), "Walking the talk. Banks gearing up to manage risks from climate change and environmental degradation", November 2022.

European Commission EC, (2018), "Action Plan: Financing Sustainable Growth", 8 March 2018.

Farnè, M., & Vouldis, A. T. (2021). Banks' business models in the euro area: a cluster analysis in high dimensions. Annals of Operations Research, 305(1-2), 23-57.

Garcia-Marco, T., & Roblez-Fernandez, M. (2008). Risk-taking behavior and ownership in the banking industry: The Spanish evidence. Journal of Economics and Business, 60, 332–354.

Gillan, S. L., Koch, A., & Starks, L. T. (2021). Firms and social responsibility: A review of ESG and CSR research in corporate finance. Journal of Corporate Finance, 66, 101889.

Hannan, T. H., Hanweck, G. A., (1988), "Bank insolvency risk and the market for large certificates of deposit", Journal of Money, Credit and Banking, 20, pp. 203–211.

Hassan, M. K., Chiaramonte, L., Dreassi, A., Paltrinieri, A., & Piserà, S. (2021). The crossroads of ESG and religious screening on firm risk. Research in International Business and Finance, 58, 101500.

Henisz, W.J., McGlinch, J., (2019), "ESG, Material Credit Events, and Credit Risk", Journal of Applied Corporate Finance, 32, pp. 116-117. https://doi.org/10.1111/jacf.12352

Hesse, H., Cihák, M., (2007), "Cooperative banks and financial stability", International monetary fund working paper, 2.

Höck, A., Klein, C., Landau, A., Zwergel B., (2020), "The effect of environmental sustainability on credit risk", Journal of Asset Management, 21, pp. 90–91. https://doi.org/10.1057/s41260-020-00155-4

Hryckiewicz, A., & Kozłowski, Ł. (2017). Banking business models and the nature of financial crisis. Journal of International Money and Finance, 71, 1-24.

https://doi.org/10.5539/ijbm.v12n9p53

Hübel, B., (2020), "Do Markets Value ESG Risks in Sovereign Credit Curves?", Quarterly Review of Economics and Finance, pp. 18-23. https://doi.org/10.1016/j.qref.2020.11.003

Ingo, W., (2020) "Sense and Nonsense in ESG Ratings", Journal of Law, Finance, and Accounting, 5, pp. 37-40. http://dx.doi.org/10.1561/108.00000049

Khan, M. A. (2022). ESG disclosure and firm performance: A bibliometric and meta analysis. Research in International Business and Finance, 101668.

Kiesel, F., Lücke, F., (2019), "ESG in credit ratings and the impact on financial markets", Financial Market Institutions & Instruments, 28, pp. 276-277. https://doi.org/10.1111/fmii.12114

Kim, S., Li, Z., (2021), "Understanding the Impact of ESG Practices", Corporate Finance Sustainability, 13, pp. 13-14. https://doi.org/10.3390/su13073746

Laeven, L., Levine, R. (2006), "Bank governance, regulation and risk taking", Journal of Financial Economics, 93, pp. 259–275.

Lagasio, V., & Quaranta, A. G. (2022). Cluster analysis of bank business models: The connection with performance, efficiency and risk. Finance Research Letters, 47, 102640.

Liang, H., Renneboog, L., (2017), "On the foundations of corporate social responsibility", The Journal of Finance, 72, pp. 898–904. https://dx.doi.org/10.2139/ssrn.2360633

Maechler, A., Srobona, M., Worrell, D. (2005), "Exploring financial risks and vulnerabilities in new and potential EU member states". Second Annual DG ECFIN Research Conference on Financial Stability and the Convergence Process in Europe, October 6–7.

Mamatzakis, E., & Bermpei, T. (2015). The effect of corporate governance on the performance of US investment banks. Financial Markets, Institutions & Instruments, 24(2-3), 191-239.

McKinsey, (2020), "A test of resilience: Banking through the crisis, and beyond", pp. 38-39.

Mergaerts F., Vennet R., (2016), "Business models and bank performance: A long-term perspective", Journal of Financial Stability, No. 22, pp. 57–75.

Murtagh F., Legendre P., (2014), "Ward's Hierarchical Agglomerative Clustering Method: Which Algorithms Implement Ward's Criterion?", Journal of Classification, No. 31, pp. 274-295. https://doi.org/10.1007/s00357-014-9161-z.

Olmedo, E.E., Fernández-Izquierdo, M.A., Ferrero, I., Rivera-Lirio, J.M., Muñoz-Torres, M.J., (2019), "Rating the Raters: Evaluating how ESG Rating Agencies Integrate Sustainability Principles", Sustainability,11, pp. 13-14. https://doi.org/10.3390/su11030915

Palmieri E., Geretto E.F., Polato M., (2022), "Performance ESG e impatti sulle probabilità di default a medio-lungo termine: il caso europeo", Bancaria Sezione Forum, 6.

Paltrinieri, A., Dreassi, A., Migliavacca, M., & Piserà, S. (2020). Islamic finance development and banking ESG scores: Evidence from a cross-country analysis. Research in International Business and Finance, 51, 101100.

Passmore S. W., (1985), "Strategic groups and the profitability of banking", Research Paper, No. 8501, Federal Reserve Bank of New York.

Pwc., (2019), "Business Model Analysis: quali strategie per vincere la sfida della redditività". Available at: https://www.strategyand.pwc.com/it/en/media/business-model-analysis-00.pdf

Roengpitya R., Tarashev N.A., Tsatsaronis K., (2014), "Bank business models", BIS Quarterly Review, December, pp. 55–65, available at: https://www.bis.org/

Rousseeuw P. J. (1986), "Silhouettes: A graphical aid to the interpretation and validation of cluster analysis", Journal of Computational and Applied Mathematics, No. 20, pp. 53–65. https://doi.org/10.1016/0377-0427(87)90125-7.

Sassen, R., Hinze, A.K., Hardeck, I. (2016), "Impact of ESG factors on firm risk in Europe", Journal of Business Economics, 86, pp. 867–904. https://doi.org/10.1007/s11573-016-0819-3

Stellner, C., Klein, C., Zwergel, B., (2015), "Corporate social responsibility and Eurozone corporate bonds: The moderating role of country sustainability. Journal of Banking & Finance, 59, p. 548. https://doi.org/10.1016/j.jbankfin.2015.04.032

Stubbs, W.P.R., (2013), "Lifting the veil on environment-social-governance rating methods", Social Responsibility Journal, 9, pp. 636-637. https://doi.org/10.1108/SRJ-03-2012-0035

Tirloni G., Antonietti A., (2020), "Le nuove Linee Guida EBA sulla concessione e monitoraggio del credito", KPMG, p. 2.

Toma P., Stefanelli V., (2022), "What are the banks doing in managing climate risk? Empirical evidence from a position map", Ecological Economics, 200, 107530. https://doi.org/10.1016/j.ecolecon.2022.107530

Volgarino A., (2017), "Il ruolo della Business Model Analysis nell'ambito del processo SREP", Bancaria, No. 3, pp. 56-57.

Ward Jr., Joe H., (1963), "Hierarchical Grouping to Optimize an Objective Function", Journal of the American Statistical Association, Vol. 58, No. 301, pp. 236–244. https://doi.org/10.2307/2282967.

Yang, A. S., Yulianto, F. A., 2021. Cost of equity and corporate social responsibility for environmental sensitive industries: Evidence from international pharmaceutical and chemical firms. Finance Research Letters, 102532. https://doi.org/10.1016/j.frl.2021.102532.

8. Appendix

Appendix 1. List of variables.

	Dependent Variables	Clustering	ESG	Capital Structure	Risk	Other
BB_5Y_DEFAULT_PROB	x					
BB_4Y_DEFAULT_PROB	x					
BB_3Y_DEFAULT_PROB	x					
BB_2Y_DEFAULT_PROB	x					
BB_1YR_DEFAULT_PROB	x					
RETURN_ON_ASSET	x					
RETURN_COM_EQY	x					
DEPOSITS_TO_ASSETS		x				
INTERBANK_ASSET_TO_TOT_ASSET		x				
BS_TOT_LOAN		x				
BS_TOT_ASSET		x				
BS_TOTAL_DERIVATIVE_ASSETS		x				
ASSETS_UNDER_MGMT_TO_ASSETS		x				
BS_RISK_WEIGHTED_ASSETS		x				
ESG_DISCLOSURE_SCORE			x			
ENVIRON_DISCLOSURE_SCORE			x			
SOCIAL_DISCLOSURE_SCORE			x			
GOVNCE_DISCLOSURE_SCORE			x			
CAST_TOT_SUB_DEBT_AMT_OUTSTDG				x		
CAST_AMT_OUTSTDG_TOTAL_DEBT				x		
CAST_AMT_OUTSTDG_TOT_UNSEC_DEBT				x		
CAST_AMT_OUTSTDG_SUB_BONDS				x		
CAST_AMT_OUTSTDG_SR_UNSEC_BONDS				x		
CAST_AMT_OUTSTDG_PFD_SHARES				x		
CAST_AMT_OUTSTDG_PFD_SHARES				x		
CAST_AMT_OUTSTDG_JR_SUB_BONDS				x		
BS_CE_TIER_1_RATIO_FULLY_LOADED					x	
BLOOMBERG_ISSUER_DEFAULT_SCORE					x	
BS_ST_BORROW						x
BS_LT_BORROW						x
TOTAL_EQUITY						x
TOT_DEBT_TO_TOT_EQY						x
TOT_DEBT_TO_TOT_ASSET						x
BS_CUSTOMER_DEPOSITS						x
SHORT_AND_LONG_TERM_DEBT						x
BS_DERIV_NON-HEDGING_TOT_LIABS						x

Appendix 2. Variables Summary.

	PD5	PD3	PD1	DEP_TA	INT_TA	DER_TA	LOAN_TA	AUM_TA	RWA_TA
Min	0,27%	0,13%	0,03%	22,23	0,54	0,19	19,88	0,71	16,50
1 Quart.	0,97%	0,69%	0,38%	45,70	3,79	1,81	43,28	19,53	28,31
Median	1,32%	1,01%	0,61%	55,84	7,76	3,68	53,08	35,36	36,68
Average	1,48%	1,15%	0,74%	55,27	9,05	5,76	53,09	52,76	40,45
3 Quart.	1,81%	1,44%	0,96%	66,67	12,07	6,65	63,40	60,48	46,43
Max	5,78%	5,20%	4,28%	89,47	32,22	37,99	81,00	281,56	90,00

	ESG	ENV	SOC	GOV	ROA	ROE	TIER1	DEF_SCORE	DEBT_TA
Min	21,49	0,48	5,35	45,06	-1,59	-27,69	6,00	1,00	0,82
1 Quart.	47,04	28,72	25,91	82,48	0,37	6,00	10,87	2,00	14,39
Median	52,19	35,28	33,80	87,72	0,67	9,86	12,10	4,00	19,00
Average	51,10	33,81	34,49	85,65	0,63	8,90	12,88	4,59	22,26
3 Quart.	56,37	39,63	42,20	92,35	0,91	13,26	14,43	7,00	29,18
Max	71,02	61,64	63,33	100,00	2,10	27,16	25,10	13,00	58,10

	EQUITY	DEBT_EQY	S_L_DEBT	ST_BORROW	LT_BORROW	DEP	SUB_DEBT	TOTAL_DEBT	UNSEC_DEBT
Min	8,20	2,18	6,37	2,30	2,20	10,03	10,82	13,46	13,12
1 Quart.	9,93	5,30	10,95	9,70	9,17	12,13	15,15	17,73	16,51
Median	10,88	5,68	12,09	10,84	11,24	13,02	16,01	18,44	17,63
Average	10,74	5,64	11,78	10,51	10,74	12,79	15,98	18,17	17,33
3 Quart.	11,38	6,10	12,81	11,75	12,04	13,54	17,11	18,99	18,29
Max	13,79	7,20	14,71	14,52	14,18	15,89	18,07	24,69	23,00

	SUB_BONDS	UNSEC_BONDS	JR_SUB_BONDS	DER_ASSETS	LOAN	TA	AUM	RWA
Min	8,85	13,12	8,06	5,38	9,78	10,70	8,15	9,36
1 Quart.	14,67	16,46	13,73	8,82	11,99	12,70	11,51	11,64
Median	15,69	17,50	14,81	10,47	12,98	13,65	12,31	12,68
Average	15,52	17,14	14,69	10,06	12,76	13,43	12,34	12,45
3 Quart.	16,49	18,16	16,18	11,34	13,51	14,29	13,37	13,04
Max	17,49	19,16	17,32	13,55	15,70	16,27	15,18	15,81

Appendix 3. Bank business models after clustering.