



# **How important are large banks in Europe and what are the potential consequences of their rising sizes?**

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## **Abstract**

**Title:** How important are large banks in Europe and what are the potential consequences of their rising sizes?

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The growing trend of major banks and the 2007-2009 financial crisis have opened the discussion over the potential impacts of large banks and the risks that these might pose to national economies. This dissertation examines the evolution of bank sizes as well as its effects on their returns, business model, and market discipline, through the analysis of a sample of financial institutions from the Europe Union for the period between 2001 and 2021. We find that, banks tend to grow systemically larger both at an industry and individual level especially in the periods prior to or after the financial crisis, possibly due to the perceived benefits of the “too-big-to-fail” effect. However, our findings also suggest that, while absolute size has a positive impact on bank returns, systemic size shows no significant relationship with performance, and neither size measures appear to be linked with bank risk either. This suggests that a bank growing to systemically large sizes will not necessarily result in greater returns for the bank’s shareholders. At the same time, we conclude that the “too-big-to-fail” effect tends to generally dominate the “too-big-to-save” effect when it comes to the discipline imposed on banks by the market and its depositors. Despite some evidence suggesting higher sensitivity of systemically large banks’ funding cost to its risk profile, estimates reveal less overall market discipline for large banks in the form of lower interest expenses and higher deposit growth rates.

**Keywords:** *absolute size, systemic size, bank performance, market discipline, financial crisis*

## **Resumo**

**Título:** How important are large banks in Europe and what are the potential consequences of their rising sizes?

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A tendência crescente dos principais bancos e a crise financeira de 2007-2009 abriram a discussão sobre os potenciais impactos dos grandes bancos e os riscos que estes podem representar para as economias nacionais. Esta dissertação examina a evolução do tamanho dos bancos, bem como seus efeitos sobre seus retornos, modelo de negócio e disciplina de mercado, através da análise de uma amostra de instituições financeiras da União Europeia para o período entre 2001 e 2021. Descobrimos que os bancos tendem a crescer sistemicamente tanto a nível da indústria quanto individual, especialmente nos períodos anteriores ou posteriores à crise financeira, possivelmente devido aos benefícios do efeito "demasiado grande para falhar". No entanto, descobrimos também que, embora o tamanho absoluto tenha um impacto positivo nos retornos do banco, o tamanho sistêmico não apresenta relação significativa com o desempenho, e nenhuma das medidas de tamanho parece estar relacionada ao risco bancário. Isto sugere que um banco que cresce para tamanhos sistemicamente grandes não resultará necessariamente em maiores retornos para os acionistas do banco. Concluimos também que, o efeito "demasiado grande para falhar" tende a dominar o efeito "demasiado grande para ser salvo" quando se trata da disciplina imposta aos bancos pelo mercado e depositantes. Apesar de algumas evidências sugerirem maior sensibilidade do custo de financiamento dos bancos sistemicamente grandes em relação ao seu perfil de risco, as estimativas revelam, de forma geral, menos disciplina de mercado para grandes bancos na forma de menores despesas de juros e maiores taxas de crescimento de depósitos.

**Palavras-chave:** tamanho absoluto, tamanho sistêmico, desempenho, disciplina de mercado, crise financeira

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## **1. Introduction**

The behavior of significantly large financial institutions has long been a topic of discussion across the United States and Europe, given the potential impacts that they can have on the financial well-being of the global economy. Most recently, the 2007-2009 crisis has illustrated the capacity of large banks to bring about significant financial consequences, where governments were forced to intervene in order to contain the severe backlash from failing banks. Given the significant connection between national banks and their power over financial markets, the collapse of one of these larger institutions can result in ripple effects and lead to the downfall of other banks as well. Thus, in an attempt to break this “snowball” effect that could endanger countries’ public finances, policymakers can feel obligated to use national funds to rescue financially failing banks. This implicit safety net has incentivized financial institutions to grow considerably compared to the size of the associated country’s economy, being persuaded by the possibility of higher returns and lower funding costs with no apparent associated risk due to expected public support if need be. Consequently, economies became more fragile in the years leading up to the financial crisis and eventually crumpled with a series of bankruptcies across the banking industry throughout 2007-2009.

Looking back, the financial crisis brought serious consequences to many stakeholders apart from banks, including the deterioration of many economies and the destabilization of households’ finances. Essentially, according to data provided by the IMF, it triggered an economic recession where European banks sustained crisis-associated losses of around €1 trillion during 2007-2010, losses which also amounted to 8% of GDP within the European Union. This was partially because, at that time, major financial institutions had grown to disproportionate sizes in comparison to their national economies, posing a threat to public finances in the form of systemic risk. Prime examples of this are the distress of the banking system in Ireland, which in 2010 was forced to be rescued by the EU and the IMF, or the failure of large banks in Iceland, which prompted the country’s bankruptcy in 2008. In the latter, the liabilities of its banking system had risen to around 9 times Iceland’s GDP at the time, leaving its authorities no choice but to let three of the largest banks in the country fail.

It begs the question if some countries will be able to rescue large financial institutions in the event of another crisis, or if instead should be the role of individual banks to control for size-associated risk and protect their own solvency. Alternatively, regulators could impose stricter policies on the financial system in order to possibly force sizable institutions to downsize or split up. An example of how these could be achieved indirectly is through policies

like the Dodd-Frank Act passed in 2010 in the United States, which aimed at limiting mergers depending on the size of the liabilities of the banks involved. Additionally, more direct approaches to controlling bank sizes have also been under discussion in the United Kingdom, with institutions like the Bank of England being an active player in the debate regarding the potential separation of major UK banks in order to safeguard national funds.

Thus, our goal was to shed more light on the possible impacts of large banks in the EU, especially regarding the benefits and costs associated with systemic size, given that the influence of larger banks relative to their national economies appears to be less intuitive. For this purpose, our study examines how banks of multiple sizes differ in terms of performance, business model, and market discipline. This includes an analysis of how size affected their achieved returns, risk profiles, funding strategy, and activity focus, and whether larger sizes result in stricter discipline by the market and depositors. Not only that but, we also provide an examination of the size evolution of the European banking industry, including the analysis of the overall distribution of systemic size within our sample, its average variation over time, as well as a look into the top largest institutions throughout the sample period. This will shed further light on the past behavior of large banks, revealing if financial institutions have been growing even bigger in an attempt to benefit from the “too-big-to-fail” effect or have downsized to limit the potential costs of the “too-big-to-save” effect, both of which would become evident in the remaining empirical results from our models.

The investigation relies on data for the 20-year period between 2001-2021 from banks in the European Union<sup>1</sup>, allowing for a diversified set of absolute and systemic sizes (including multiple economies of distinctive magnitudes) and covering both periods of economic expansion and financial crisis.

Recent events have made this topic even more prominent, as the aftermath of the coronavirus pandemic threatens once more the stability of the European financial system. Prior to that, global debt levels had already been soaring, due partially to the significantly low interest rates. However, according to the Institute of International Finance, that number was further pushed to \$15 trillion in 2020, as countries struggled to protect their economies. As a consequence of the recent quantitative easing strategy, inflation rates rose dramatically in 2022

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<sup>1</sup> This includes the countries of Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden. Note that, despite the United Kingdom exiting the European Union in 2020, banks from the UK were still included in the dataset given their systematic importance in the European financial scene throughout the majority of the period under analysis.

and policymakers were thus forced to increase interest rates for the first time in several years<sup>2</sup>. Eventually, this sudden change in monetary policy and shift in depositors' confidence led to the financial distress of major banks like Silicon Valley Bank and Credit Suisse, which ultimately collapsed in 2023<sup>3</sup>. At the time of this study, the true impact of these incidents remains yet to be seen, however, the chain of events partially resembles concerns felt throughout the years of economic volatility leading up to the last financial crisis.

After an initial examination of the evolution of bank's liabilities-to-GDP ratio, we see a trend of growing systemic size both at an industry and individual bank level, especially in periods prior and after the financial crisis. This is possibly due to the potential benefits of a large systemic size that can be realized by banks during periods of economic prosperity, which may come in the form of greater returns or lower market discipline as a result of the "too-big-to-fail" effect. Our results further show that there is a positive correlation between a bank's absolute size and its performance according to return on assets and return on equity, while the impact of systemic size proved insignificant overall. At the same time, the relationship between both bank size measures and associated bank risk (measured by Z-score) also appears unclear. The lack of impact of systemic size on bank performance is a consequence of the share of banks with a considerably high liabilities-to-GDP ratio, which is insufficient to make a significant difference in the distribution of both performance measures. Despite this, it would be rash to assume that systemic size poses zero interest to a bank's shareholders, given the possibility of it having some sort of indirect effects on bank performance and risk. To a certain extent, an increase in systemic size could mean an increase in absolute size as well, which in turn would affect positively a bank's returns as suggested by our evidence.

Regarding their business models, there seems to be a tendency for systematically larger banks to prioritize fee-generating activities and rely less on deposits for their short-term funding. Similarly, larger banks in absolute terms tend to derive a greater proportion of their income from non-interest-related activities but place more emphasis on deposit funding, while exhibiting lower leverage and higher levels of capitalization, with relatively smaller holdings of loans. These observations imply that systematically larger banks adopt a less conventional structure and approach compared to larger banks in absolute terms.

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<sup>2</sup> According to WDI data, inflation rate in the Euro Area as of 2022 was around 8.5% (a value last seen only in 1983). Additionally, European Central Bank's interest rates reached 3% as of February 2023, which was last seen that high in 2008 during the financial crisis as well.

<sup>3</sup> In the first half of 2023, the Silicon Valley Bank in the US was shut down due partially to a sudden increase in withdrawals and placed under the Federal Deposit Insurance Corporation, while Credit Suisse in Europe collapsed given in part to liquidity problems and was bought out by rival UBS.

Finally, with respect to market discipline, we conclude that the interest expense of banks that are large relative to their economy tend to be more responsive to changes in their capitalization levels. This heightened sensitivity of financing expenses to bank risk may indicate more rigorous market discipline and provide support for the notion of a "too-big-to-save" effect, wherein stakeholders perceive systemically large banks to be challenging to rescue in the event of insolvency. Conversely, the absence of market discipline was also apparent from the inverse relationship between interest expenses and both measures of bank size, as well as the positive correlation between absolute size and deposit growth. These findings suggest that the "too-big-to-fail" effect outweighs any "too-big-to-save" considerations.

This study includes sections regarding the review of previous work around this topic, a description of methods for the investigation and respective variables, an outline of the results obtained, and a conclusion of our work and possibilities for future work.

## **2. Literature review**

This paper follows and elaborates on previous studies concerning the size of banks, respective performance and risk, and market discipline. In fact, the relationship between these concepts within the financial sector has long been studied by the likes of O'Hara & Shaw (1990). After conducting an event study to analyze equity price behavior following a US government announcement that classified some banks as too-big-to-fail in 1984, they found a positive stock price reaction of the institutions classified as such. This was the first time this relationship was witnessed, as the study concluded that the TBTF ("too-big-to-fail") categorization resulted in a wealth increase for those large banks and the opposite effect occurred for smaller banks. These findings then paved the way for further studies dealing with bank size and performance. For instance, Berger & Mester (1997) estimated the optimal size for a bank to be around \$25 billion in assets, using US banking returns from the 1990s. Later however, Wheelock & Wilson (2012) found that most US banks between 1985 and 2006 benefited from increasing returns to scale, suggesting that economies of scale are a possible reason behind the growth in average bank size throughout the sample period.

Other studies also examined the extent of the relationship between the size of financial institutions and both idiosyncratic and systemic risk. Papers such as Varotto & Zhao (2018) attempted to form banking policy recommendations by developing determinants of systemic

risk. They established that, despite size being a potential promoter of systemic risk, smaller banks can further contribute to the same type of threats. Thus, they propose standardized risk measures to account for additional risk factors apart from size. Laeven et al. (2016) further focused on absolute bank size and found it positively related to systemic risk but negatively related to bank capital. Other similar relationships with bank size were further examined, such as in Demirgüç-Kunt & Huizinga, (2010) where for a global group of banks, they found both non-interest income and non-deposit funding to have a positive impact on bank absolute size.

Up until Demirgüç-Kunt & Huizinga (2013), there was no evidence that accounted for absolute and systematic size as separate determining factors of bank performance and market discipline, by evaluating independently their impact on bank's equity and market-to-book value for a sample of international banks. The authors of the paper discovered a negative correlation between a bank's market-to-book value and both size measures, with a stronger negative relationship in countries with substantial public deficits. This supports the notion that large banks relative to the size of their economies can become too big to be rescued, revealing that those banks could improve their book-to-market value through downsizing, referred to as the TBTS ("too-big-to-save") effect. This was especially true for countries with weaker financial health, where the ability to carry out large rescues is limited, reducing net subsidies to the banking sector. Together with Bertay et al. (2013), they were the first researchers to conclude that, for larger banks, the TBTS effect tends to predominate over the TBTF effect. The study in question discovered that the responsiveness of interest rates to a bank's risk increased with systematic size. This finding implies that depositors might be more likely to enforce stricter regulations on larger banks if they anticipate that the state's ability to cover their losses is limited and that these larger banks have become too big to fail.

Other more recent studies, such as Acharya et al. (2016), have attempted to enhance the understanding of how markets relate to the TBTF effect and how this affects the pricing of the bank's funding costs. Through the analysis of bond spreads of financial institutions, they concluded that debtholders of major US banks were confident that authorities would protect their losses if need be, eventually leading to underestimations of risk. Other papers like Santos (2014) further tested the "too-big-to-fail" hypothesis, finding that the largest banks tend to have a greater advantage in the form of cheaper debt funding.

Furthermore, a study by Flannery & Sorescu (1996) provided further insight into the market discipline of banks by finding that spreads on debentures of banks better reflected their risk as a financial institution after procedural alterations that raised the risk of default on these securities. Essentially, they arrived to the conclusion that as the regulatory approach to failed

banks' debt got harsher, spreads on bank-subordinated debentures were more closely connected with indices of bank risk.

The TBTF effect and its problematic impact on banks' undisciplined behavior in the market have also been studied in the scope of mergers in the financial industry. In the paper Kane (2000) an analysis was conducted on the mergers of US banks that took place between 1991 and 1998. The study concluded that the stockholders of large bank acquirers experienced an increase in value when the target deposit institution was substantial in size, and this increase was even more pronounced when both parties of the deal had the same location in terms of US states. A similar conclusion was reached by Benston et al. (1995), who showed that higher insurance of instruments like put options could drive further M&A activity within the banking sector. Also, Penas & Unal (2004) performed an analysis of the returns to bondholders in the context of US bank mergers that occurred between 1991 and 1997. The results showed that the adjusted returns on the bonds of merging banks were positive during both the pre-merger and announcement months.

Another body of study has also shown that banks that are deemed to be TBTF act ethically risky, increasing their risk-taking activities in anticipation of government bailouts. This body of literature provides proof that TBTF status affects financial institutions' policies. For example, some studies look at the balance-sheet data of banks (Farhi et al., 2009; R. Gropp et al. (2011), while others look at the syndicated bank facilities (Gadanecz et al., 2012). In particular, Afonso et al. (2014) investigate this issue by focusing on banks that have been identified by rating agencies as likely to get support from the government and by employing several metrics of bank risk. This study sets itself apart from other research by estimating the probability of a bank receiving sovereign support using Fitch's support rating floors (SRFs), which were made accessible in March 2007. The authors came to the conclusion that a bank's willingness to take on risk does grow with the likelihood of government support. However, there is also evidence to suggest that greater public backing tends to turn financial institutions more risk-averse, thus this result is not universally accepted (R. E. ; Gropp & Vesala, 2004; Kacperczyk & Schnabl, 2011).

The discussion around banks' size and their impact on financial markets was also further extended in order to explore other regions or similar effects. Brown & Dinç (2011) for instance, introduced the "too-many-to-fail" effect after analyzing a sample of financial institutions in emerging countries throughout the 1990s. The study found that a government is less likely to intervene in the case of a failing bank by either taking over it or closing it if other banks within the same country are also in a weakened state. This phenomenon, referred to as

the "too-many-to-fail" effect, was also more pronounced for larger banks and even more so with an increase in the government's budget deficit. This implies that as the government's budget deficit grows, the likelihood of the government intervening in the case of a failed bank decreases. Moreover, other papers addressed the TBTF effect and associated market discipline in light of banking crises. Cubillas et al. (2012) conducted an analysis of 23 financial crises that occurred in 18 different economies and discovered that, on average, market discipline was weakened after each crisis. In a subsequent study by the same authors Cubillas et al. (2017), an international sample was taken from 104 countries and analyzed in the period leading up to the 2007 financial crisis. The conclusion reached was that the TBTF effect was stronger in countries that did not impose losses on depositors during previous banking crises and in countries with more robust public finances. These findings suggest that when a crisis is addressed by a more accommodating set of regulations, the loss of market discipline is higher. A hypothesis that was further supported by the studies of Demirgüç-Kunt & Huizinga (2004) and Nier & Baumann (2006), which demonstrated that broader safety nets also have a detrimental effect on market discipline by comparing nations in whether or not there was a banking crisis. Lastly, in a more recent study, Barth & Wihlborg (2016) attempted to address these concepts from a broader perspective by analyzing the TBTF and TBTS dilemma together within a population of the largest worldwide banks throughout the 1984-2015 period. In their paper, the authors identify various dimensions of the "too-big-to-fail" phenomenon and examine the impact of a bank's size relative to its national economy on its convoluted status. They conclude that absolute and relative size are not the sole determinants of TBTF status and that high complexity is, in fact, a significant factor. Not only that but, they further evaluate several reforms proposed following the financial crisis and determine that although some progress has been made and further improvements are being pursued, these measures may not provide a comprehensive solution to the TBTF problem.

### **3. Data and methodology**

In this dissertation, I examined a sample of banks from the EU over the 2002-2021 period, retrieving respective balance sheet and income statement information from WRDS (Compustat). In order to ensure data accessibility and quality, the sample was also restricted to publicly listed banks only.

This study uses data from several nations to assess two key independent variables, namely a bank's absolute and relative or systemic size. The balance sheet and income statement data of the banks were used to calculate these variables. The log of the bank's assets is utilized as the *Assets* variable to represent their absolute size, whereas the liabilities-to-GDP ratio of the bank (*Liabilities over GDP*) measures a country's highest potential spending in case of a bank rescue compared to its GDP, as a representation of systemic size. It should be noted that WRDS does not include off-balance sheet data, which may affect the absolute and systemic size. These are, however, accounted for in the income statement, so the gross income and the ratio of gross income to GDP are used as substitute measures of absolute size and systemic size, respectively, in order to also test for the robustness of the original size measures.

Table 1 shows summary statistics of the main variables used, where one can see *Assets*, the measure of bank absolute size, has a sample mean of 23.945. As for the bank's systemic or relative size, the *Liabilities over GDP* measure reported a mean of 0.165. Additionally, Figure 1 illustrates the distribution of the *Liabilities over GDP* variable. The majority of banks proved to be smaller in comparison to the local economy, with 56.37% of them reporting a liabilities-to-GDP ratio lower than 0.05. Still, a number of banks in the sample are considerably large in terms of relative size, with close to 6% of them having liabilities between 10% and 15% of GDP, 24.24% with liabilities exceeding 15% of GDP, and 3.51% of banks revealing liabilities larger than GDP.

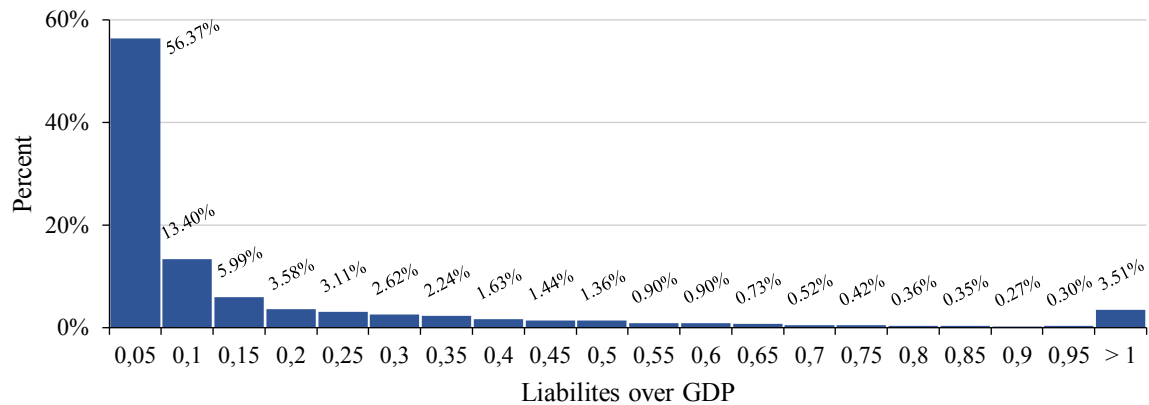
In the empirical study that follows, three main dependent variables are used to study the relationship between both bank size measures and respective performance and risk. As profitability indices, we used both *Return on assets* and *Return on equity*, calculated by dividing pre-tax profits by assets and equity respectively. The first has a mean of 0.004, while the latter presents a mean value of 0.067. Thirdly, the *Z-score* (the index for bank solvency) is calculated by dividing the product of return on assets and capital assets ratio by the return on assets' standard deviation. The latter variable reveals how much can the return on assets vary in order to remain solvent, with the likelihood of bankruptcy being reduced when the *Z-score* is higher. Between 2003 and 2021, five consecutive 4-year periods were used to compute the bank's *Z-score*, which ended up reporting a mean value of 23.128. Furthermore, six additional dependent variables are used to examine the bank's business model in addition to the previous three profitability variables. The first of them is *Fee income*, which is represented by the portion of operating income that comes from sources other than interest, such as fees, commissions, and trading income.

**Table 1: Summary statistics**

Variable	Obs	Mean	Std. dev.	Min	Max
Assets	19197	23.945	2.428	12.628	38.328
Liabilities	19153	10.341	1.100	3.477	16.551
Gross income	21397	19.600	2.395	6.802	35.907
Liabilities over GDP	19141	0.165	0.361	0	3.600
Gross income over GDP	21248	0.010	0.266	-0.554	1.351
Return on assets	16850	0.004	0.132	-1.427	0.266
Return on equity	12446	0.067	1.523	-1.831	1.244
Z-score	7054	23.128	42.634	-0.134	172.496
Fee income	21161	0.204	3.482	-4.528	16.711
Interest income	16383	0.011	0.010	-0.101	0.482
Other operating income	16570	0.001	0.194	-17.66	0.608
Loans	17524	0.534	2.293	0	1.497
Non-deposit short-term funding	11359	0.424	5.087	0	1
Interest expense	14865	0.105	0.416	0	3.476
Deposit growth	21127	0.089	0.199	-0.091	2.889
Equity	12485	0.167	1.044	0	1
Liquidity	18478	0.196	0.139	0.443	12.703
Overhead	15780	0.006	0.016	-0.109	1.113
Short-term debt	18471	0.443	0.895	0	1
Investment bank	24895	0.026	0.157	0	1
Non-banking credit institution	24895	0.019	0.139	0	1
Other bank	24895	0.003	0.055	0	1
Inflation	24747	0.039	0.043	-0.044	0.544
GDP growth	24882	0.021	0.263	-0.058	0.454
GDP per capita	24794	14.191	7.618	-14.758	23.200

This table reports summary statistics for our main bank and country variables. Assets is the natural logarithm of total assets in constant 2010 euros. Liabilities represent the natural logarithm of total liabilities in constant 2010 euros. Liabilities over GDP stands for a bank's liabilities divided by GDP. Gross income is the natural logarithm of gross income in constant 2010 euros. Gross income over GDP is bank gross income divided by GDP. Return on assets and Return on equity is pre-tax profits divided by total assets and equity respectively. Z-score is an index of bank solvency constructed for five consecutive 4-year periods as  $(ROA+CAR)/SROA$ , where ROA is return on assets, CAR represents capital assets ratio and SROA stands for standard deviation of return on assets. Fee income represents the share of non-interest income in total operating income. Interest income stands for the interest income minus interest expense divided by assets. Other operating income is other operating income divided by total assets. Loans stands for the total loans divided by earning assets. Non-deposit short-term funding is the share of non-deposit short-term funding in total deposits and other short-term funding. Equity is equity divided by assets. Interest expense represents interest expense over bank liabilities excluding non-interest-bearing debt. Deposit growth is the growth rate of a bank's customers and short-term funding. Liquidity is liquid assets divided by customer and other short-term funding. Overhead represents personnel expenses and other non-interest expenses over total assets. Short-term debt is customer and short-term funding divided by total interest-paying debt. Investment bank, Non-banking credit institution, and Other bank are dummy variables that equal 1 for the respective bank categories and zero otherwise. Inflation is the annual change in consumer prices. GDP growth stands for the inflation-adjusted growth rate of GDP per capita of the country. GDP per capita is GDP per capita in thousands of constant 2010 euros.

**Figure 1.** Histogram for the liabilities-to-GDP ratio. It shows the percentages of banks with Liabilities over GDP in consecutive 0.05 bins, with the last one including banks with a ratio over 1.



This indicator assesses how significant non-interest income-generating activities are for a bank in comparison to conventional interest-generating operations, with an average of 20.4% coming from this type of income for our sample. The *Interest income* measure reported an average of 0.105, consisting of income from interest-related activities divided by assets. Similarly, the *Other operating income* variable, which represents a bank’s non-interest income as a share of its assets, shows a mean of 0.001. Also, in order to measure customer focus and loan generation intensity, we used a bank’s loans and divided it by its earning assets. The mean *Loans* value is 0.534. *Non-deposit short-term funding*, which is essentially the share of total funding apart from deposits, is built on the liability side as well, showing a mean value of 0.424. A greater non-deposit short-term financing share suggests that the bank engages with non-deposit wholesale funding more frequently and with traditional bank depositors less frequently. The *Equity* variable, which is calculated as bank equity divided by total assets, is then used to calculate the bank's overall leverage and reported an average of 16.7% in our sample.

The effect of bank size on market discipline is also investigated in this study. Market discipline is the practice of depositors and other holders of bank liabilities keeping an eye on a troubled bank's financial situation. For it, this can mean both higher interest rates on liabilities and slower deposit growth. Two variables—*Interest expense* and *Deposit growth*—are considered to gauge the impact of market discipline. Interest expenditure is calculated as the interest expense as a percentage of all obligations with an interest-bearing component, which resulted in a mean value of 0.105. Also, the yearly percentage growth rate of actual deposits is used to determine deposit growth, with the sample revealing an average rate of 0.089. The

equity and Z-score variable are then used as representations of bank risk, in order to evaluate the hypothesis that banks that carry a larger risk of failing may expect to see more market discipline. As for illiquidity risk, a *Liquidity* variable is also included, determined by the ratio of liquid assets to customers and short-term funding, which was 19.6% on average.

The analysis considers a number of controls at the country and bank levels as well. *Overhead* and *Short-term debt* are computed as the ratio of wages and other expenditures to assets and short-term debt over liabilities, respectively. *Overhead* mean value was 0.006, whereas for *Short-term debt* was 0.443. An additional three categorical variables were also created that describe the type of bank and thus account for potential differences that affect their activities and overall performance. The first is *Investment bank*, a binary variable with the value of one for securities firms and investment banks and zero for all other firms. The second is another binary variable, *Non-banking credit institution*, which designates a non-banking credit institution. The third dummy variable is *Other bank*, which can refer to further non-traditional banks (cooperative banks, credit banks, real estate banks, among other forms of financial institutions). In our sample, 2.6% of banks are included in the first category, 1.9% are included in the second one, and 0.3% in the latter category. Finally, the analysis also takes into account macroeconomic variables at the national level, such as the inflation rate, the GDP per capita (in constant euros), and its growth rate. Each reported mean values of 0.029, 14.191, and 0.021 respectively.

**Table 2:** Correlations for main variables

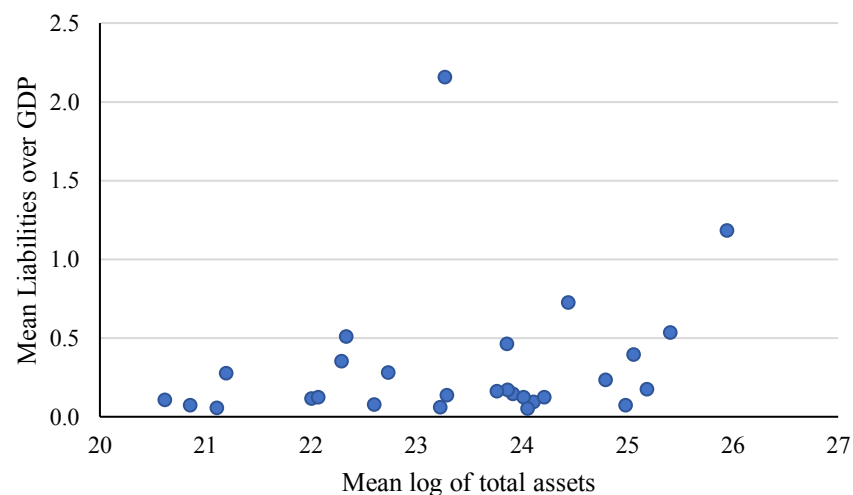
	Assets	Liabilities over GDP	Gross income	Gross income over GDP	Return on assets	Return on equity	Z-score	Fee income	Non-deposit short-term funding	Interest expense	Deposit growth
Assets	1										
Liabilities over GDP	0.309***	1									
Gross income	0.915***	0.746***	1								
Gross income over GDP	0.226***	0.929***	0.231***	1							
Return on assets	0.059***	0.003	0.059***	0.002	1						
Return on equity	0.018**	0.003	0.011	0.002	0.072***	1					
Z-score	-0.002	0.001	-0.004	-0.000	-0.004	-0.001	1				
Fee income	-0.001	-0.001	0.000	-0.000	0.000	-0.009	0.006	1			
Non-deposit short-term funding	-0.013	-0.001	-0.021**	-0.001	-0.002	-0.001	-0.001	-0.001	1		
Interest expense	-0.010	-0.001	0.011	-0.001	0.012	0.000	-0.002	-0.001	-0.001	1	
Deposit growth	0.052***	0.151***	-0.009	0.055***	0.001	0.001	-0.000	-0.002	-0.0001	0.000	1

This table reports the pairwise correlations of the bank variables. Variables are described in Table 1.

\* Significance at 10%; \*\* Significance at 5%; \*\*\* Significance at 1%.

Additionally, Table 2 shows the pairwise correlations between the main variables used in this study, including both measures of bank size, performance, and market discipline. Firstly, it is worth noticing the relatively low and significant (at 1% confidence level) correlation of 0.309 concerning *Assets* and *Liabilities over GDP*, justifying the distinction between the absolute and systemic size measures in our empirical analysis. This evidence is further demonstrated in Figure 2, a scatter plot of the means of assets and liabilities-to-GDP ratio per country, which illustrates the low correlation between both bank size measures. Furthermore, Table 2 also reveals that both bank size variables are positively correlated with the two performance measures (*Return on assets* and *Return on equity*), as well as positively and negatively correlated to *Interest expense* and *Deposit growth* respectively. These hint towards the possibility that larger sizes can lead to greater returns and less discipline from the market. Still, these hypotheses will be further examined in the empirical section of this report. Also, the fact that both *Assets* and *Liabilities over GDP* are highly correlated with *Gross income* (0.915 and 0.746 respectively), shows that these measures are sound proxies of bank size even though they are based on balance sheet values.

**Figure 2.** Scatter diagram of means of assets and liabilities-to-GDP ratio. This figure shows a scatter diagram of mean values of the natural logarithm of total assets and the liabilities to GDP ratio per country.



#### 4. The Empirical evidence

This part of the report includes the empirical analysis completed for the purpose of our study. It begins with an overview development of the banking industry in the European Union,

in order to identify certain trends across the sample size, including the impact of the 2008 financial crisis. After that follows an analysis of results regarding the impact of bank size on respective returns and business model. Then, a consideration of the relationship between both bank size measures and discipline through funding costs and variation of deposits. Finally, this section also reports on how different the relationship between bank size and returns, business model, and market discipline is depending on economic stability.

#### ***4.1. Evolution of systemically large banks***

Out of the sample used, the banks that are significantly large relative to the national economy are the ones more likely to cause substantial damage to an entire financial system if they were to fail. For this reason, *Liabilities over GDP* is used as the main variable to assess the progression of systemically (relative to the size of their respective economies) large banks in the European Union between 2001 and 2021.

Table 3 shows 36 publicly listed banks with a liabilities-to-GDP ratio of over 0.5, including the year they achieve their maximum level of liabilities-to-GDP ratio. Note that, the years 2001 and 2020 were the ones with more banks reaching the maximum level of the systemic size measurement, with 8 banks for both years. This pattern can also be observed to a certain extent if we focus on banks with a *Liabilities over GDP* value above 1, with 6 out of 17 banks achieving the maximum ratio in either 2001 or 2020 (and 3 banks in 2010). Thus, it appears that banks tend to become systemically larger in periods prior to or after the financial crisis, during times of more favorable economic conditions. This is further illustrated by Figure 3, which shows the evolution of the systemic size measure, liabilities-to-GDP ratio, where the yearly average is displayed across the period the sample period of 2001 to 2021. Apart from the overall increasing trend across the entire time frame, it is worth noticing the rise from its lowest point of 0.132 in 2004 to 0.148 in 2007, while tumbling once more to 0.137 during the 2008 economic downturn. This is followed by a more consistent growing trend up until 2021 throughout economic recovery years, with sharper upsurges in 2015 and 2020 where it hit its maximum of 0.219. By 2021, Norway's Nordea Bank reported the highest systemic size at 1.944, with the remaining 4 systemically largest institutions reporting higher liabilities than their respective country's GDP in that year (Appendix 2).

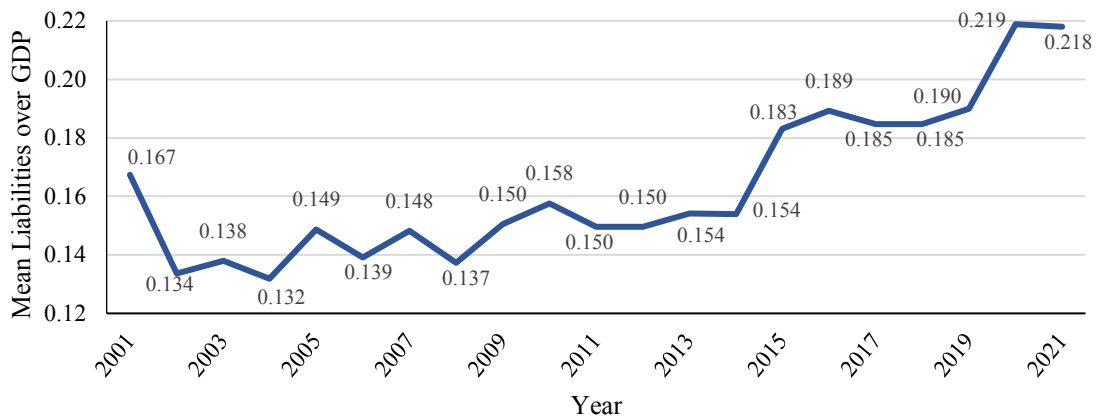
**Table 3:** Systemically large banks between 2001 and 2021

Bank	Country code	Year	Max Liabilities over GDP	Assets
SVENSKA HANDELSBANKEN	SWE	2003	3.600	27.862
SWEDBANK AB	SWE	2010	3.535	28.244
PROBANKA	SVN	2004	3.317	25.582
NORDEA BANK ABP	FIN	2015	2.973	27.311
JYSKE BANK	DNK	2019	1.810	27.219
BNP PARIBAS FORTIS SA	BEL	2007	1.692	27.426
BANK OF CYPRUS HOLDINGS PLC	CYP	2010	1.579	24.489
CYPRUS POPULAR BANK PCL	CYP	2010	1.535	24.491
UNICREDIT BANK SLOVAKIA AS	SVK	2007	1.503	25.685
DEXIA SA	BEL	2001	1.446	26.585
ABN-AMRO HOLDINGS NV	NLD	2001	1.385	27.144
MONETA MONEY BANK AS	CZE	2020	1.213	26.504
BANCO SANTANDER SA	ESP	2020	1.160	28.084
DEPFA BANK PLC	IRL	2002	1.117	25.706
SWISS NATIONAL BANK	CHE	2020	1.102	27.630
BANK OF GREECE	GRC	2021	1.090	26.194
HSBC HLDGS PLC	GBR	2020	1.028	28.724
BNP PARIBAS	FRA	2020	0.970	28.614
KBC GROUP NV	BEL	2001	0.921	26.153
TWEST GROUP PLC	GBR	2009	0.895	28.437
BANK OF VALLETTA LTD	MLT	2016	0.856	23.096
BANK OF IRELAND GROUP PLC	IRL	2006	0.784	25.964
UNICREDIT BANK AUSTRIA AG	AUT	2001	0.777	25.796
AIB GROUP PLC	IRL	2001	0.758	25.210
CREDIT AGRICOLE SA	FRA	2020	0.721	28.312
BARCLAYS PLC	GBR	2008	0.684	28.350
HANSABANK	EST	2001	0.659	22.250
HSBC BANK MALTA PLC	MLT	2015	0.651	22.762
CREDIT AGRICOLE INDOSUEZ	FRA	2001	0.647	27.603
HELLENIC BANK	CYP	2021	0.624	23.659
DEUTSCHE BANK AG	DEU	2012	0.619	28.438
ERSTE GROUP BK AG	AUT	2021	0.594	26.457
BANQUE NATIONALE DE BELGIQUE	BEL	2021	0.592	26.608
BBVA	ESP	2015	0.581	27.343
SOCIETE GENERALE GROUP	FRA	2016	0.565	28.010
ABN AMRO BANK NV	NLD	2015	0.552	26.806

This table shows a list of banks with a Liabilities over GDP value of over 50%. Max Liabilities over GDP represents the maximum value for the variable reached by each bank over our timeframe. Assets is the log of total assets for each bank in that year.

Interestingly, among these systemically large institutions, 2 Nordic banks and 1 Slavic bank show the highest liabilities-to-GDP ratio, including Svenska Handelsbanken, Swedbank, and Probanka at 3.600 in 2003, 3.535 in 2010, and 3.317 in 2004 respectively. However, banks like Komerčni Banka in the Czech Republic, Nordea Bank in Finland, and Swiss National Bank in Switzerland, were consistently in the top 5 banks in the EU regarding systemic size throughout the entire timeframe (Appendix 2).

**Figure 3.** Yearly mean of the Liabilities over GDP measure between 2001 and 2021. It includes the 481 banks covered in our sample.



Additionally, Table 3 reveals that, when considering the absolute size measure, the largest banks are HSBC in the United Kingdom, BNP Paribas in France, and Deutsche Bank in Germany, with *Assets* value of 28.724 in 2020, 28.614 also in 2020, and 28.438 in 2012 respectively. Meaning that, the systemically largest banks aren't necessarily the largest ones in absolute terms.

Concluding this section, Table 4 provides further insights into our comparison between banks in terms of sizes relative to their economies throughout the time period. More specifically, it includes panels for 2009 and 2021, and the means of our main bank and country measures, distinguishing between systemically larger (liabilities-to-GDP ratio exceeding 50%) and smaller (liabilities-to-GDP ratio of 50% or lower) banks. Systemically larger banks reported higher mean *Return on assets* and *Return on equity* in both time panels. Simultaneously, systemically large banks show a considerably lower *Z-score* in 2009 but higher in 2021, suggesting that they are riskier in periods of financial crisis. Moreover, in 2021, those same larger banks showed lower *Fee income*, higher *Interest income*, and lower *Other operating income*. In that same period, systemically larger banks have lower *Loans*, higher *Interest expense*, and higher *Equity*. Interestingly, out of the 6 last mentioned variables, 5 reported the opposite behavior in 2009 regarding the comparison between systemically large and small banks, further emphasizing the importance of accounting for the economic cycle phase when evaluating the impact of bank's size in performance or market discipline.

**Table 4:** Systemically large and small banks throughout and post-financial crisis

Variables	Total		Liabilities over GDP<0.5		Liabilities over GDP≥0.5		Mean comparison test t-Statistic
	N	Mean	N	Mean	N	Mean	
<b>Panel A: 2009</b>							
Assets	1306	23.735	1159	23.348	101	26.248	-15.376
Liabilities	1306	10.253	1159	10.082	101	11.367	-15.458
Gross income	1551	19.540	1076	19.136	91	21.682	-12.213
Liabilities over GDP	1306	0.835	1159	0.072	101	1.105	-15.346
Gross income over GDP	1576	0.017	1111	0.001	97	0.017	-7.431
Return on assets	1256	0.001	1117	0.001	98	0.001	-1.287
Return on equity	1137	0.008	1064	0.001	43	0.021	-1.230
Z-score	125	20.468	111	21.394	13	13.770	2.076
Fee income	1565	0.176	1102	0.184	97	0.205	-0.750
Interest income	1227	0.014	1092	0.014	94	0.011	2.803
Other operating income	1246	0.001	1108	0.000	97	0.002	-4.365
Loans	1219	0.632	1074	0.700	99	1.007	-2.190
Non-deposit short-term funding	799	0.328	700	0.299	69	0.769	-1.234
Interest expense	1121	0.067	1002	0.055	78	0.031	1.473
Deposit growth	1268	-0.002	842	-0.003	82	0.001	1.777
Equity	1137	0.066	1064	0.052	43	0.089	-1.663
Liquidity	1264	0.153	1119	0.162	99	0.106	0.401
Overhead	1176	0.006	1042	0.006	94	0.003	5.915
Short-term debt	1264	0.815	1119	0.629	99	0.847	-3.075
Investment bank	1684	0.026	1159	0.028	101	0.059	-1.318
Non-banking credit institution	1684	0.018	1159	0.020	101	0.000	4.842
Other bank	1684	0.004	1159	0.003	101	0.000	2.003
Inflation	1676	0.227	1159	0.219	97	0.142	0.590
GDP growth	1684	0.007	1159	0.001	101	0.011	0.062
GDP per capita	1684	1.901	1159	1.897	101	1.902	0.020
<b>Panel B: 2021</b>							
Assets	1102	24.616	905	24.039	135	26.828	-20.389
Liabilities	1102	10.634	905	10.381	135	11.605	-20.343
Gross income	1188	19.869	852	19.227	126	22.243	-18.171
Liabilities over GDP	1094	1.386	905	0.097	135	1.052	-20.133
Gross income over GDP	1188	0.026	878	0.001	130	0.017	-10.526
Return on assets	1076	0.003	883	0.003	131	0.004	-2.365
Return on equity	1087	0.024	883	0.021	131	0.039	-4.508
Z-score	564	11.696	446	10.221	72	15.482	-2.807
Fee income	1184	0.298	870	0.321	129	0.190	2.026
Interest income	1050	0.008	861	0.007	128	0.011	-4.899
Other operating income	1063	0.001	872	0.001	130	0.001	0.758
Loans	1042	0.725	856	0.864	125	0.714	1.716
Non-deposit short-term funding	770	0.853	622	1.015	95	0.181	12.279
Interest expense	956	0.011	781	0.010	117	0.014	-2.106
Deposit growth	1044	0.003	745	0.000	119	0.005	-0.830
Equity	1102	0.182	905	0.156	135	0.198	-0.719
Liquidity	1067	0.290	870	0.291	135	0.329	-0.183
Overhead	1038	0.004	855	0.004	124	0.004	1.361
Short-term debt	1066	0.478	869	0.388	135	0.562	-0.681
Investment bank	1262	0.026	905	0.028	135	0.000	5.068
Non-banking credit institution	1262	0.021	905	0.022	135	0.044	-1.210
Other bank	1262	0.003	905	0.004	135	0.000	2.003
Inflation	1254	0.388	905	0.348	135	0.695	-1.837
GDP growth	1254	0.081	905	0.022	135	0.141	1.006
GDP per capita	1254	18.412	905	17.551	135	19.259	1.292

This table presents summary statistics for the subsamples of banks with a liabilities-to-GDP ratio that exceeds and are less than 1. The last column presents the t-statistics for comparison tests between means of systemically large and small banks. Assets is the natural logarithm of total assets in constant 2010 euros. Liabilities represent the natural logarithm of total liabilities in constant 2010 euros. Liabilities over GDP

stands for a bank's liabilities divided by GDP. Gross income is the natural logarithm of gross income in constant 2010 euros. Gross income over GDP is bank gross income divided by GDP. Return on assets and Return on equity is pre-tax profits divided by total assets and equity respectively. Z-score is an index of bank solvency constructed for five consecutive 4-year periods as  $(ROA+CAR)/SROA$ , where ROA is return on assets, CAR represents capital assets ratio and SROA stands for standard deviation of return on assets. Fee income represents the share of non-interest income in total operating income. Interest income stands for the interest income minus interest expense divided by assets. Other operating income is other operating income divided by total assets. Loans stands for the total loans divided by earning assets. Non-deposit short-term funding is the share of non-deposit short-term funding in total deposits and other short-term funding. Equity is equity divided by assets. Interest expense represents interest expense over bank liabilities excluding non-interest-bearing debt. Deposit growth is the growth rate of a bank's customers and short-term funding. Liquidity is liquid assets divided by customer and other short-term funding. Overhead represents personnel expenses and other non-interest expenses over total assets. Short-term debt is customer and short-term funding divided by total interest-paying debt. Investment bank, Non-banking credit institution, and Other bank are dummy variables that equal 1 for the respective bank categories and zero otherwise. Inflation is the annual change in consumer prices. GDP growth stands for the inflation-adjusted growth rate of GDP per capita of the country. GDP per capita is GDP per capita in thousands of constant 2010 euros.

## ***4.2. Performance and business model***

The goal of these first regression models was to examine the impact of bank size in their performance and strategy. For this purpose, several regressions were constructed using proxies of performance and business model on both absolute (*Assets*) and systemic (*Liabilities over GDP*) size measures, for which associated results are presented in Table 5. Note that, all regressions include bank and time fixed effects, except regression 3 which only includes year fixed effects according to the construction of the *Z-score* variable.

In the first regression, where one can examine the impact of the bank size variables on *Return on assets* (the first proxy for bank performance), the absolute size measure presents an estimated significant (at the 1% level) coefficient of 0.004. This suggests that large absolute size leads to an increasing rate of return on assets, which in turn can mean greater returns for the average bank. At the same time, the variable for systemic size, also reveals a positive coefficient of 0.001. Should it have been more significant, it would have hinted towards the possibility that return on assets also increases with relative size. Additional information provided by regression 1 further corroborates the possibility that the variable for systemic size may not be critical for the explanation of the general change in bank's return on assets. This is because it entails that a one standard deviation increase in *Liabilities over GDP* (of 0.361 from Table 1) increases a bank's rate of return on assets by 0.04%<sup>4</sup>. Considering that this represents

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<sup>4</sup> Calculated by multiplying the variable's coefficient in the regression (0.001) by its overall sample standard deviation (0.361).

only 0.3% of the standard deviation of return on assets of 0.132, this small effect means that the majority of banks in the sample have significantly small *Liabilities over GDP* measure, and that the ones with a greater ratio are too few to meaningfully impact the general change of the *Return on assets* variable. Apart from that, regarding the control variables included in regression 1, return on assets also has a positive and significant relationship with *Equity* (capitalization rate) and *GDP per capita*, as well as a negative relation with *Inflation* (annual inflation rate of the respective country). It can also be observed that institutions classified as investment banks (which can include credit, real estate, mortgage banks, etc.) achieve a lower rate of return on assets than non-banking credit institutions.

Similarly, regression 2 also has the goal of investigating a bank's performance, but this time using *Return on equity* as the dependent variable. As in the previous regression, the *Assets* variable reports a significant coefficient of 0.022, whereas the measure for systemic size has a positive but not significant coefficient of 0.006. Thus, a similar reasoning as regression 1 applies, that is, the rate of return on equity increases alongside bank's absolute size but the impact of systemic size is unclear. The coefficient of 0.022 for measurement of absolute size implies that a one standard deviation increase in a bank's assets (2.428) increases its return on equity by 5.3%, consisting of 3.5% of the standard deviation of *Return on equity* of 1.523<sup>5</sup>.

As for regression 3, the measures of absolute and systemic bank size seem to be unrelated to bank risk (proxied by the *Z-score*), as the coefficients for *Assets* and *Liabilities over GDP* returned insignificant. Thus, according to these first three regressions, it appears that while absolute bank size can be associated with greater returns, the same was not verified regarding the systemic size. Moreover, bank risk also proved unaffected by either measure of size.

Afterward, I studied how the same bank size measures impacted its respective business model and strategy by considering dependent variables that serve as indices for earnings and funding mix, and asset allocation. This way, regression 4 reflects on the impact on *Fee income*, a gauge of the dependence on non-interest income of financial institutions. Here, the measure for absolute size has an estimated coefficient of 0.011 (significant at 10%), meaning that, larger banks in terms of absolute size have higher non-interest income, which is consistent with the conclusions pointed out by (Demirgüç-Kunt & Huizinga, 2010).

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<sup>5</sup> A one standard deviation increase in *Liabilities over GDP* has the following effects on variables in Table 5 measured in percentages of standard deviations where the coefficient for the given variable is significant: *Fee income*, 0.05; *Interest income*, -18.05; *Other operating income*, 2.05; *Non-deposit short-term funding*, 61.03; *Equity*, -1.00.

**Table 5:** Model testing for bank performance and business model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ROA	ROE	Z-score	Fee income	Interest income	Other operating income	Loans	Non-deposit short-term funding	Equity
Assets	0.004*** (0.000)	0.022** (0.013)	-1.182 (2.020)	0.011* (0.026)	-0.003*** (0.000)	0.000 (0.000)	-3.213*** (5.916)	-1.112*** (1.102)	0.528*** (0.016)
Liabilities over GDP	0.001 (0.000)	0.006 (0.012)	28.557 (5.744)	0.005*** (0.007)	-0.005*** (0.000)	0.011*** (0.061)	1.498 (8.392)	8.600*** (2.968)	-0.029*** (0.004)
Equity	0.015*** (0.002)	0.001*** (0.022)	2.311 (29.136)	-0.014 (0.017)	0.004*** (0.001)	-0.005*** (0.000)	5.227* (3.001)	1.868*** (4.758)	
Short-term debt	0.000 (0.000)	0.001 (0.003)	-1,102*** (3.577)	0.046*** (0.001)	0.067*** (0.002)	-0.018*** (0.001)	4.859 (4.707)	1.019 (7.084)	0.000 (0.001)
Investment bank	-0.035* (0.011)	-0.001*** (0.001)	-13.633 (4.136)	0.037 (0.007)	-0.039 (0.031)	0.002 (0.001)	0.152** (0.599)	-0.511*** (0.233)	-0.048*** (0.007)
Non-banking credit institution	0.002* (0.001)	0.066 (0.001)	-5.248 (9.441)	-0.672 (0.003)	-0.002 (0.007)	0.0812** (0.054)	0.238** (0.490)	0.173 (0.551)	-0.011 (0.008)
Other bank	0.000 (0.015)	-0.031 (0.018)	3.478 (5.284)	0.088 (0.040)	-0.050 (0.022)	0.003 (0.020)	-0.246 (0.127)	-0.120 (0.313)	0.034 (0.014)
Inflation	-0.001*** (0.002)	-0.001 (0.098)	102.590*** (32.562)	0.006*** (0.004)	0.009*** (0.000)	0.071** (0.000)	-1.365 (8.968)	1.535 (1.711)	-0.009*** (0.002)
GDP growth	0.036 (0.000)	-0.003 (0.004)	-133.641 (114.511)	0.001 (0.00204)	-0.219*** (0.612)	-0.197 (0.183)	-3.547 (4.562)	6.320*** (9.221)	0.004*** (0.001)
GDP per capita	0.002*** (0.001)	0.011** (0.003)	13.340* (16.412)	-0.004** (0.003)	-0.719*** (0.009)	-0.009* (0.000)	1.311* (7.416)	-1.918 (1.348)	-0.002 (0.003)
<i>N</i>	11250	11250	5833	11555	11444	11573	11155	8186	11944
R-sq	0.159	0.115	0.101	0.122	0.281	0.197	0.104	0.185	0.276

Return on assets and Return on equity is pre-tax profits divided by total assets and equity respectively. Z-score is an index of bank solvency constructed for five consecutive 4-year periods as  $(ROA+CAR)/SROA$ , where ROA is the return on assets, CAR represents capital assets ratio and SROA stands for the standard deviation of return on assets. Fee income represents the share of non-interest income in total operating income. Interest income stands for the interest income minus interest expense divided by assets. Other operating income is other operating income divided by total assets. Loans stands for the total loans divided by earning assets. Non-deposit short-term funding is the share of non-deposit short-term funding in total deposits and other short-term funding. Equity is equity divided by assets. Assets is the natural logarithm of total assets in constant 2010 euros. Liabilities over GDP stands for a bank's liabilities divided by GDP. Short-term debt is customer and short-term funding divided by total interest-paying debt. Investment bank, Non-banking credit institution, and Other bank are dummy variables that equal 1 for the respective bank categories and zero otherwise. Inflation is the annual change in consumer prices. GDP growth stands for the inflation-adjusted growth rate of GDP per capita of the country. GDP per capita is GDP per capita in thousands of constant 2010 euros. All regressions except regression 3 include bank and time fixed effects. \*Significance at 10%; \*\* Significance at 5%; \*\*\* Significance at 1%.

A similar conclusion can be drawn when considering the measure for systemic size, given that the *Liabilities over GDP* measure reports a positive and significant coefficient as well. This possibly implies that, whether a bank is larger in absolute terms or relative to its

national economy, it could be more advantageous for the institution to focus on its fee income-generating activities.

Regressions 5 and 6 enable the examination of the relationship between bank size and respective earnings measured by interest and non-interest income respectively. In the first one, the *Assets* and *Liabilities over GDP* measures had a negative and significant coefficient at the 1% level of -0.003 and -0.005 respectively. As for the latter, with *Other operating income* (non-interest income) as the dependent variable, while *Assets* reports an insignificant coefficient, the one for *Liabilities over GDP* was of 0.011 and significant at 1%. The estimations from both regressions allow us to further conclude that, as hypothesized before, both large banks in absolute and relative terms concentrate relatively more on activities that generate non-interest income.

Next, regression 7 uses *Loans* as the dependent variable to inspect the impact of bank size on the share of loans in total bank earnings. Results show that only absolute size has a significant relationship with the dependent variable, with *Assets* reporting an estimated negative coefficient of -3.213. This insinuates that, larger banks in absolute terms tend to allocate a smaller portion of earnings to loans, perhaps because loan growth was inferior to overall growth for larger banks despite their size relation to their national economies.

As for regression 8, I considered how the bank size variables affected the share of a bank's short-term funding that is not generated from deposits. Both coefficients for *Assets* and *Liabilities to GDP* were significant at the 1% level, with the first one reporting a negative relationship with the dependent variable and the latter a positive relationship. Thus, it appears that systemically larger banks rely more on non-deposit funding, while banks that are larger in absolute terms tend to opt for deposits as a source of short-term funding.

In the final regression, the *Equity* variable was used to account for a bank's capital structure. While the coefficient for the bank absolute size measure was positive (significant at the 1% level), it was negative for *Liabilities over GDP* (significant at 1% also). Suggesting that, larger banks in absolute terms are better capitalized and less leveraged, whereas the reverse is true for systemically larger institutions.

When it comes to our overall results regarding the effect of size on respective business models and strategy, it appears that systemically larger banks follow a less traditional structure, with more focus on fee income and non-deposit funding. As for large banks in absolute terms, they revealed a more hybrid approach, with emphasis on fee income but a reduced non-deposit funding share.

To finalize this section of the empirical results, we examined the robustness of the previous models by replacing the bank size variables of *Assets* and *Liabilities over GDP* with the *Gross income* and *Gross income over GDP* (with the remaining control variables and regression options analogous to the models in Table 5). As described by Table 6, the results are rather similar. This is specifically exemplified by the significant and positive estimated coefficients for *Gross income* and insignificant coefficients for *Gross income over GDP*, in both regressions concerning bank returns (regression 1 and 2). As for strategy, regressions 4-9 corroborate that systemically large banks focus on non-interest income and on attracting non-deposit funding. On the other hand, large banks in absolute terms also rely on non-interest income but gravitate towards deposit funding, tend to generate fewer loans, and maintain higher capitalization levels.

**Table 6:** Model testing for bank performance and business model with alternative bank size measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ROA	ROE	Z-score	Fee income	Interest income	Other operating income	Loans	Non-deposit short-term funding	Equity
Gross income	0.001*	0.012***	3.402	-0.025	-0.002***	0.005***	-1.464***	-1,056***	0.036***
	(0.000)	(0.021)	(1.246)	(0.022)	(0.000)	(0.001)	(5.350)	(10.130)	(0.007)
Gross income over GDP	-0.000	-0.101	-28.263	0.079	-0.0084***	0.006***	1.697	1.664***	-0.045
	(0.003)	(0.187)	(12.151)	(0.160)	(0.005)	(0.001)	(3.610)	(6.205)	(0.051)
Equity	0.010***	0.016	7.444	0.010	-0.000	-0.011***	1.358	1.365	
	(0.001)	(0.032)	(23.498)	(0.029)	(0.000)	(0.001)	(6.722)	(1.053)	
<i>N</i>	10980	10980	5459	11241	11146	11251	10549	7697	11251
R-sq	0.134	0.015	0.061	0.021	0.145	0.234	0.062	0.182	0.012

Return on assets and Return on equity is pre-tax profits divided by total assets and equity respectively. Z-score is an index of bank solvency constructed for five consecutive 4-year periods as  $(ROA+CAR)/SROA$ , where ROA is the return on assets, CAR represents capital assets ratio and SROA stands for the standard deviation of return on assets. Fee income represents the share of non-interest income in total operating income. Interest income stands for the interest income minus interest expense divided by assets. Other operating income is other operating income divided by total assets. Loans stands for the total loans divided by earning assets. Non-deposit short-term funding is the share of non-deposit short-term funding in total deposits and other short-term funding. Equity is equity divided by assets. Gross income is the natural logarithm of gross income in constant 2010 euros. Gross income over GDP is bank gross income divided by GDP. All regressions except regression 3 include bank and time fixed effects. In regression 3 variables are mean values over 4-year periods, the regression includes bank and time fixed effects. The variables Short-term debt, Investment bank, Non-banking credit institution, Other bank, Inflation, GDP growth and GDP per capita are included in the regressions but not reported. Standard errors are given in parentheses.

\* Significance at 10%; \*\* Significance at 5%; \*\*\* Significance at 1%.

### ***4.3. Market discipline***

This subsection of the report uses the same sample of banks from the European Union to examine if, in fact, there is a tendency for stricter market discipline for larger banks. According to the research, bigger financial institutions in the United States tend to be "too big to fail," which lowers the cost of money and lessens depositor market discipline due to bank risk. (Flannery & Sorescu, 1996) discovered that spreads on banks' subordinated debentures during 1983-1984 did not reflect bank risk, but instead declined with bank asset size, despite the evidence also suggesting the extent of the "too big to fail" effect could change with time. Spreads on subordinated debentures, on the other hand, did not take asset size into account during the period between 1989 and 1991, when the notion of "too big to fail" subsidies was less common<sup>6</sup>.

Bank depositors have two options for disciplining a risky bank: they either withdraw their funds or ask for a higher interest rate. This is why, to explore this rationale, we look at how a bank's size and risk profile affect its average interest rate and deposit growth rate. For this purpose, in regressions of the average interest rate and deposit growth rate, we added interaction factors between a bank's risk indicator and its size variable. While a bank's increased market discipline is shown by a negative estimated coefficient for such an interaction variable in the interest expense regressions (showing that bigger banks are more susceptible to bank risk as evidence of the "too-big-to-save" effect), the same conclusion can be drawn from a positive coefficient for the same variables in the deposit growth regressions (meaning that deposit growth is more responsive to bank risk for larger institutions). Previous studies have also examined the relationship between deposit insurance and market discipline, such as Demirgüç-Kunt & Huizinga (2004), who found that deposit insurance can indeed reduce discipline. However, this effect seems to vary across time and geography, given that the work of Soledad et al. (2001) finds that deposit insurance does not diminish market discipline when considering some Latin American countries<sup>7</sup> during the 1980s and 1990s decades.

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<sup>6</sup> Baker & McArthur (2009) found that, for the period of 2000-2007, larger US banks in absolute terms had cost of funds that were on average 0.29% lower than smaller banks, and an even wider gap was witnessed from the end of 2008 to the beginning of 2009. These results further illustrate the impact of "too big to fail" benefits, especially during the 2007-2009 economic downturn.

<sup>7</sup> Such as Argentina, Chile and Mexico.

### 4.3.1. Market discipline via interest expense

In Table 7, we can observe the results of regressing our first proxy variable for market discipline on indices for bank size and risk, as well as additional control variables. Thus, regression 1 uses *Interest expense* as the dependent variable representing market discipline, and *Assets*, *Liabilities over GDP*, and *Equity* for indicators of absolute size, relative size, and capitalization respectively. Results reveal negative and significant (at the 1% level) coefficients for both measures of bank size, suggesting that larger banks in absolute and relative terms face lower interest expenses, and thus hitting towards the possibility that they are less susceptible to market discipline as a benefit from the “too-big-to-fail” effect. Note that, the Equity variable proxying for bank risk returns an insignificant coefficient.

Next, regression 2 is equal to the first one apart from the additional interaction term of *Equity* and *Liabilities over GDP*, in order to test for the relationship between market discipline and the capitalization rate of systemically large banks. The estimated coefficient for the liabilities-to-GDP ratio variable is -0.002 which is significant at 5%, and for the interaction term the coefficient was also a negative one of -0.009 which is also significant. The latter suggests a negative relationship between interest expense and bank capitalization for the ones with high systemic size. More specifically, the coefficients imply that *Interest expense* declines with *Equity* if the *Liabilities over GDP* measure rise above 0.444<sup>8</sup>, which is significantly higher than this ratio’s mean of 0.165 (see Table 1).

Furthermore, because the previous regression focuses on the extent of market discipline regarding systemic size, regression 3 examines the same effect but for both size measures, by adding an interaction term for bank absolute size. Once again, the coefficient for the interaction term between *Equity* and *Liabilities over GDP* was negative and significant, while the one between *Equity* and *Assets* returns an insignificant coefficient. Thus, it appears that market discipline through interest expense is more consistent based on systemic bank size.

To further examine the relationship between bank risk and respective interest expense, in regression 4, the previously used interaction terms with bank size variables are replaced by the *Z-score* and by its respective interaction terms. The *Z-score* variable alone yields an insignificant coefficient, but the variable for the liabilities-to-GDP ratio and the interaction term has estimated coefficients of opposite signs that are both significant at 10%.

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<sup>8</sup> Calculated by dividing the coefficient of the *Equity* variable (0.004) by the coefficient of the interaction term (-0.009) in regression 2 in absolute terms.

**Table 7: Model testing for market discipline via interest expense**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Interest expense	Interest expense	Interest expense	Interest expense	Interest expense	Interest expense	Interest expense	Interest expense	Interest expense
Assets	-0.020*** (0.018)	-0.020*** (0.018)	-0.022* (0.018)	-0.010** (0.011)	-0.017 (0.014)	-0.034* (0.020)	-0.041* (0.024)	-0.008*** (0.027)	
Liabilities over GDP	-0.001*** (0.005)	-0.002** (0.008)	0.000** (0.008)	0.004* (0.000)	0.002** (0.000)	0.003* (0.000)	-0.017*** (0.007)	-0.001* (0.011)	
Equity	0.004 (0.012)	0.004 (0.012)	-0.219 (0.772)					0.002 (0.013)	-0.680 (1.416)
Equity*Liabilities over GDP		-0.009*** (0.072)	-0.013** (0.074)					-0.017 (0.092)	
Equity*Assets			0.012 (0.041)						
Z-score/100				-0.009 (0.001)					
Z-score*Liabilities over GDP				-0.003* (0.000)					
Liquidity					-0.001*** (0.000)				
Liquidity*Liabilities over GDP					0.002 (0.001)				
Gross income						0.019 (0.012)	0.032 (0.020)		
Gross income over GDP						0.003* (0.000)	0.021* (0.311)		
Equity*Gross income over GDP							-0.241*** (1.212)		
Fee income								-0.003 (0.007)	
Non-deposit short- term funding								-0.000 (0.000)	
Liabilities									0.001** (0.003)
Equity*Liabilities									-0.001 (0.001)
N	10185	10185	10185	5950	13983	13450	9927	7069	10185
R-sq	0.103	0.142	0.112	0.045	0.111	0.024	0.138	0.098	0.063

The dependent variable is Interest expense, which represents a bank's interest expense over its liabilities excluding non-interest-bearing debt. Assets is the natural logarithm of total assets in constant 2010 euros. Liabilities represent the natural logarithm of total liabilities in constant 2010 euros. Liabilities over GDP stands for a bank's liabilities divided by GDP. Gross income is the natural logarithm of gross income in constant 2010 euros. Gross income over GDP is bank gross income divided by GDP. Fee income represents the share of non-interest income in total operating income. Non-deposit short-term funding is the share of non-deposit short-term funding in total deposits and other short-term funding. Equity is equity divided by assets. Z-score is an index of bank solvency constructed for five consecutive 4-year periods as (ROA+CAR)/SROA, where ROA is return on assets, CAR represents capital assets ratio and SROA stands for standard deviation of return on assets. Liquidity is liquid assets divided by customer and other short-term funding. All regressions are estimated using bank and time fixed effects (except regression 4). In regression 4 variables are mean values over 4-year periods, the regression includes bank and time fixed effects. The variables Overhead, Short-term debt, Investment bank, Non-banking credit institution, Other bank, Inflation, GDP growth and GDP per capita are included in the regressions but not reported. Standard errors are given in parentheses.

\* Significance at 10%; \*\* Significance at 5%; \*\*\* Significance at 1%.

Suggesting that, higher *Z-score* changes the original relationship between a bank's systemic size and interest expense, which is further evidence of market discipline given the greater responsiveness of funding costs to bank risk. Regression 5 has a similar goal, but this time using *Liquidity* as the index for bank risk, as well as the interaction term with *Liabilities over GDP*. Although the interaction term shows an insignificant coefficient, the one for the liquidity variable was -0.001 and significant at 1%, implying that banks with a larger share of liquid assets face lower interest expenses.

Next, regression 6 is similar to the first one but it uses alternative measures of bank size instead, including *Gross income* and *Gross income over GDP* to replace the previously used variables for absolute and systemic size. While the estimated coefficient for *Gross income* was insignificant, interest expense seems to rise for banks with a higher gross income-to-GDP ratio as suggested by the positive and significant estimated coefficient. However, this appears to be the case only if a bank's capitalization is less than 0.087 ( $=0.021/0.241$ ), as shown by regression 7 where an interaction term was added between *Equity* and *Gross income over GDP*. Its negative and significant estimated coefficient corroborates the too-big-to-save hypothesis, given that it provides additional confirmation of market discipline on systemically large banks through funding costs.

From the regressions used to examine bank performance depending on size in Table 5, we saw how the measure for absolute size was positively and negatively related to fee income and non-deposit funding respectively, while systemic size showed a positive relation to both dependent variables. Therefore, it is relevant to test if the effect of bank size on interest expense is solely a consequence of its funding strategies. For this purpose, in regression 9, the variables *Fee income* and *Non-deposit short-term funding* were added as controls. Although the coefficients for these controls returned insignificant, the negative and significant estimated coefficients for both *Assets* and *Liabilities over GDP* further confirm the negative relationship between bank size and interest expense. This adds to the evidence for the "too-big-to-fail" effect consistent with poorer market discipline for large banks in absolute and relative terms.

Finally, regression 9 tests for a possible relationship between an alternative single-size measure and interest expense. This new *Liabilities* variable has an estimated coefficient of 0.001 which is significant at 5%, suggesting a potential positive effect of a bank's real liabilities on interest expense.

Overall, the results show a contradicting behavior of market discipline of large banks via funding expenses, due to both the "too-big-to-fail" and "too-big-to-save" effects appearing to work simultaneously. While interest expense generally falls with increasing bank absolute

and relative size (apart from banks with relatively low capitalization rates as shown by regressions 6 and 7), results also suggest, to a certain extent, enhanced market discipline of systemically larger banks given the higher sensitivity of funding costs to bank risk.

#### 4.3.2. Market discipline via deposit growth

The following set of regressions presented in Table 8 are very similar to the ones on Table 7, the difference being the dependent variable of *Deposit growth* as the proxy for market discipline.

Firstly, bank's deposit growth rate is regressed on the measures for absolute and systemic size (*Assets* and *Liabilities over GDP*) and on the variable indexing bank risk (*Equity*). Out of these, only the measure for a bank's assets reports a significant coefficient of 0.163, meaning that banks with a larger absolute size tend to witness a rise in deposit rates. Consistently with previous evidence, this further hints towards the possible benefit of the "too-big-to-fail" effect in the form of scarcer discipline of larger banks through deposits.

In regressions 2 and 3, we added an interaction term between *Equity* and *Liabilities over GDP* and between *Equity* and *Assets* respectively, in an attempt to measure the degree of sensitiveness of deposit growth to bank risk for large intuitions in absolute and systemic terms. However, the estimated coefficients for those interaction terms were negative but insignificant.

Additionally, the following regression replaces the bank risk proxy for the *Z-score* as an alternative risk measurement. Yet, coefficients for that variable and for the interaction both returned insignificant estimates. Likewise, in regression 5 *Liquidity* was used as the variable for bank risk together with its interaction term with *Equity*, where both coefficients proved to be insignificant as well.

Analogously to regression 2, regression 6 examines the influence of size on deposit growth but does so by using alternative variables for absolute (*Gross income*) and systemic size (*Gross income over GDP*). Interestingly, both show negative and significant (at the 1% level) coefficients, indicating a negative impact of absolute and relative size on a bank's deposit growth rate. Additionally, regression 7 includes the interaction term between *Equity* and *Gross income over GDP*, however, coefficients this time proved insignificant.

Regression 8 incorporates further control variables that could also potentially explain deposit growth behavior from changes in a bank's funding strategy, including *Fee income* and

**Table 8:** Model testing for market discipline via deposit growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Deposit growth	Deposit growth	Deposit growth	Deposit growth	Deposit growth	Deposit growth	Deposit growth	Deposit growth	Deposit growth
Assets	0.163** (0.077)	0.166** (0.078)	0.183** (0.079)	-0.103 (0.070)	8.907*** (2.002)	5.804*** (2.763)	0.259** (0.103)	-0.002 (0.001)	
Liabilities over GDP	0.000 (0.022)	0.008 (0.035)	-0.002 (0.036)	0.000 (0.001)	0.008*** (0.000)	0.028*** (0.001)	0.006 (0.028)	-0.001 (0.001)	
Equity	0.017 (0.047)	0.019 (0.047)	5.275 (3.260)					0.000 (0.001)	1.271*** (6.579)
Equity*Liabilities over GDP		-0.084 (0.307)	0.026 (0.314)					-0.001 (0.005)	
Equity*Assets			-0.279 (0.173)						
Z-score/100				-0.001 (0.000)					
Z-score*Liabilities over GDP				-0.001 (0.017)					
Liquidity					0.001 (0.000)				
Liquidity*Liabilities over GDP					-0.002 (0.001)				
Gross income						-6.287*** (2.370)	-0.108 (0.087)		
Gross income over GDP						-0.216*** (0.013)	-0.353 (1.800)		
Equity*Gross income over GDP							0.861 (11.400)		
Fee income								0.000 (0.001)	
Non-deposit short-term funding								-0.001 (0.000)	
Liabilities									1.427*** (0.129)
Equity*Liabilities									-1.201 (0.599)
N	10093	10093	10093	5955	13628	13266	9949	6943	10093
R-sq	0.054	0.024	0.034	0.013	0.125	0.192	0.025	0.015	0.060

The dependent variable is Deposit growth, which represents the growth rate of a bank's customers and short-term funding. Assets is the natural logarithm of total assets in constant 2010 euros. Liabilities represent the natural logarithm of total liabilities in constant 2010 euros. Liabilities over GDP stands for a bank's liabilities divided by GDP. Gross income is the natural logarithm of gross income in constant 2010 euros. Gross income over GDP is bank gross income divided by GDP. Fee income represents the share of non-interest income in total operating income. Non-deposit short-term funding is the share of non-deposit short-term funding in total deposits and other short-term funding. Equity is equity divided by assets. Z-score is an index of bank solvency constructed for five consecutive 4-year periods as  $(ROA+CAR)/SROA$ , where ROA is return on assets, CAR represents capital assets ratio and SROA stands for standard deviation of return on assets. Liquidity is liquid assets divided by customer and other short-term funding. All regressions are estimated using bank and time fixed effects (except regression 4). In regression 4 variables are mean values over 4-year periods, the regression includes bank and time fixed effects. The variables Overhead, Short-term debt, Investment bank, Non-banking credit institution, Other bank, Inflation, GDP growth and GDP per capita are included in the regressions but not reported. Standard errors are given in parentheses.

\* Significance at 10%; \*\* Significance at 5%; \*\*\* Significance at 1%.

*Non-deposit short-term funding.* The estimated coefficients obtained were positive and negative respectively, but insignificant.

Finally, regression 9 includes a measure of a bank's real liabilities as an alternative measure of bank absolute size, as well as an interaction term between *Liabilities* and *Equity*. The single-size variable has a positive coefficient significant at 1%, which is consistent with previous evidence that suggests that large banks in absolute terms can be too-big-to-fail. At the same time, the interaction term had a negative estimated coefficient that is insignificant.

Overall, unlike the results from the previous model (where market discipline was proxied through interest expenses), little evidence was found on the negative relationship between bank risk and deposit growth. In fact, the analysis further suggests less intense market discipline for banks of larger size, especially in absolute terms. Note that, this evidence lacks robustness to alternative measures of both absolute and systemic size variables, as pointed out by regression 6.

#### ***4.4. The crisis years***

The goal of this final subsection is to test if the relationships examined in the previous models were more or less evident during the period of the financial crisis between 2007 and 2011. For this purpose, we built similar regressions to the ones used in previous sections and included a measure to interact with other independent variables to account for those crisis years.

Table 9 is essentially an adaptation of Table 5, the difference being the interaction terms between measures of bank size or risk and a dummy variable to weigh the crisis years of 2007 to 2011. The first regression reveals positive and significant (at the 1% level) relationships between *Return on assets* and both *Assets* and its interaction term with the dummy for the crisis years. Meaning that the positive impact of bank absolute size on the respective rate of return on assets which had previously been corroborated as well, is intensified throughout the period of crisis. The same conclusion can be drawn from the estimated coefficients for *Equity* and its interaction term with the crisis dummy variable (that the positive impact of bank capitalization on its return on assets became even more noticeable during the 2007-2011 period), where both obtain a result that is positive and significant at 1%. As for the measure of systemic size and the associated interaction term, both coefficients were insignificant.

When using the *Return on equity* as the index for performance in regression 2, results were similar. However, this time, only the measure for absolute size and its interaction term with the dummy for the 2007-2011 period had significant coefficients. The fact that these were positive is consistent with the conclusion suggested by the previous regression, *i.e.*, that a bank's performance increases with absolute size, even during crisis years.

Regressions 3-8 aim at investigating how the effect of bank size on its funding strategy changes during the period of crisis. As seen before, larger banks in absolute terms seem to not rely so much on interest income, a pattern that was further intensified during the period of 2007-2011 (regression 4), while maintaining a lower level of loans independently of the time period (regression 6). As for systemically large banks, their funding strategy is consistent with the evidence presented before, as suggested by negative and positive significant coefficients for *Interest income* and *Non-deposit short-term funding* respectively.

**Table 9:** Model testing for bank performance and business model with crisis years interactions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ROA	ROE	Fee income	Interest income	Other operating income	Loans	Non-deposit short-term funding	Equity
Assets	0.002*** (0.000)	0.001*** (0.055)	-0.004 (0.029)	-0.003*** (0.000)	0.001*** (0.002)	-3.933*** (6.974)	-1,206*** (1.318)	0.443*** (0.016)
Assets*Crisis years	0.003*** (0.001)	0.022*** (0.041)	0.012 (0.012)	-0.001*** (0.000)	0.001*** (0.002)	6.417 (2.949)	1.984 (5.319)	-0.026*** (0.007)
Liabilities over GDP	-0.000 (0.003)	0.011 (0.039)	0.004 (0.008)	-0.001*** (0.002)	0.001 (0.000)	2.112 (1.723)	9.606*** (3.225)	-0.028*** (0.004)
Liabilities over GDP*Crisis years	0.001 (0.000)	-0.002 (0.0006)	-0.002 (0.004)	0.003*** (0.001)	-0.002 (0.001)	5.197 (9.590)	-4.014** (1.808)	0.002 (0.002)
Equity	0.012*** (0.001)	-0.005 (0.027)	-0.015 (0.018)	0.001*** (0.000)	-0.005*** (0.000)	6.825* (4.001)	2.092*** (6.320)	
Equity*Crisis years	0.044** (0.011)	1.194 (1.009)	-0.014 (0.481)	-0.004*** (0.001)	0.009** (0.004)	-3.329** (1,303)	2.590*** (2.477)	
N	11023	11023	11005	10895	11023	10359	7604	11023
R-sq	0.284	0.107	0.031	0.328	0.179	0.145	0.184	0.172

Return on assets and Return on equity is pre-tax profits divided by total assets and equity respectively. Fee income represents the share of non-interest income in total operating income. Interest income stands for the interest income minus interest expense divided by assets. Other operating income is other operating income divided by total assets. Loans stands for the total loans divided by earning assets. Non-deposit short-term funding is the share of non-deposit short-term funding in total deposits and other short-term funding. Equity is equity divided by assets. Assets is the natural logarithm of total assets in constant 2010 euros. Liabilities over GDP stands for a bank's liabilities divided by GDP. Crisis years is a dummy variable that equals 1 for the years 2007–2011 and zero otherwise. All regressions are estimated using bank and time fixed effects. The variables Short-term debt, Investment bank, Non-banking credit institution, Other bank, Inflation, GDP growth and GDP per capita and corresponding interaction variables with the crisis years dummy variable are included in the regressions but not reported. Standard errors are given in parentheses.

\* Significance at 10%; \*\* Significance at 5%; \*\*\* Significance at 1%.

Meaning that they seem to focus more on non-interest income and on non-deposit funding, however, an opposing strategy appears to be in place during crisis years. This hints towards the possible shift in funding strategy of systemically large banks towards a more traditional banking approach, perhaps to adjust to the financial struggles of national economies during the period of crisis.

Finally, in order to test the impact of bank size on market discipline throughout the period of 2007-2011, we re-estimated the first regressions of Tables 7 and 8 by including the *Crisis years* interaction term with bank size and risk variables and regressing them on same proxies of market discipline (*Interest expense* and *Deposit growth*).

From regressions 1 and 2 in Table 10, we can see negative and positive significant coefficients for the *Assets* and *Assets\*Crisis years* variables respectively. Implying that, while interest expenses generally decrease with a bank's absolute size, the opposite seems to be true for the periods of 2007-2011.

**Table 10:** Model testing for market discipline with crisis years interactions

	(1)	(2)	(3)	(4)
	Interest expense	Interest expense	Deposit growth	Deposit growth
Assets	-0.021*** (0.018)	-0.022*** (0.018)	0.102 (0.079)	0.098 (0.079)
Assets*Crisis years	0.002* (0.008)	0.003* (0.008)	0.033 (0.033)	0.038 (0.033)
Liabilities over GDP	-0.001 (0.005)	0.001 (0.008)	0.002 (0.021)	0.016 (0.037)
Liabilities over GDP*Crisis years	0.001 (0.003)	-0.013 (0.013)	-0.001* (0.012)	-0.068* (0.056)
Equity	0.004 (0.012)	0.004 (0.012)	0.0313 (0.047)	0.034 (0.047)
Equity*Crisis years	0.183 (0.296)	0.124 (0.301)	-7.520*** (1.285)	-7.810*** (1.306)
Equity*Liabilities over GDP		-0.009 (0.074)		-0.077 (0.311)
Equity*Liabilities over GDP*Crisis years		0.103 (0.093)		0.519 (0.396)
<i>N</i>	10185	10185	10093	10093
R-sq	0.046	0.057	0.128	0.129

The dependent variable in regressions 1–2 is Interest expense, which represents a bank's interest expense over its liabilities excluding non-interest-bearing debt. The dependent variable in regressions 3–4 is Deposit growth, which stands for the growth rate of a bank's customers and short-term funding. Assets is the natural logarithm of total assets in constant 2010 euros. Liabilities over GDP stands for a bank's liabilities divided by GDP. Crisis years is a dummy variable that equals 1 for the years 2007–2011 and zero otherwise. Equity is equity divided by assets. All regressions are estimated using bank and time fixed effects. The variables Overhead, Short-term debt, Investment bank, Non-banking credit institution, Other bank, Inflation, GDP growth and GDP per capita and corresponding interaction variables with the crisis years dummy variable are included in the regressions but not reported. Standard errors are given in parentheses.

\* Significance at 10%; \*\* Significance at 5%; \*\*\* Significance at 1%.

This suggests that there is a potential rise in market discipline for larger banks in absolute terms during the financial crisis. However, the remaining interaction terms regarding systemic size and bank risk reveal insignificant coefficients, suggesting that the degree of market discipline for systemically larger banks through interest expense implied by the results of Table 7 existed prior to the crisis.

Additionally, I also conducted a similar examination of market discipline in the crisis period but through deposit growth as well, using the same interaction terms as the previous 2 regressions. Results from regressions 3 and 4 reveal that, this time, the estimated coefficients for the variable of absolute bank size and its interaction term with the dummy for crisis years show insignificant results. However, the estimated coefficients for the *Liabilities over GDP\*Crisis years* and *Equity\*Crisis years* were negative and significant in both regressions. This suggests that discipline for systemically bigger institutions via deposit growth was possibly induced by the financial crisis, even for banks with a rising capitalization rate.

In the end, there seems to be some evidence to suggest that market discipline via interest expenses is entirely reversed and becomes stricter during the crisis for large banks in absolute terms. As for systemically large banks, the crisis period also appears to somewhat trigger market discipline via deposit growth.

## **5. Conclusion**

The 2007-2009 financial crisis lit the discussion around the size of financial institutions and the potential consequences of their failure to the industry and national economies. In order to better understand this policy interest around the possible benefits and costs of the magnitude of banks in the European Union, this study assesses in what way a bank's absolute and systemic size impacts their respective returns, business model, and market discipline.

After an examination of the evolution of bank's liabilities-to-GDP ratio (the variable used to proxy for systemic size), results revealed that banks became systemically smaller throughout the financial crisis, but then grew again during the period of economic recovery, following a consistently growing trend up until recent times. Not only that but, at the individual level, our sample also showed that the banks were systemically the largest in years prior to or after the crisis such as 2001 or 2020. This is possibly due to the potential benefits of a large systemic size realized by banks during periods of economic prosperity, which may come in the form of greater returns or lower market discipline as a result of the "too-big-to-fail" effect.

Further evidence of the potential benefits of considerable bank size in our sample of banks from the European Union, is the positive correlation found between both size measures (total bank assets and liabilities-to-GDP ratio) and both performance metrics (return on assets and return on equity), as well as the negative and positive correlation between the size variables and both proxies for market discipline – interest expense and deposit growth rate – respectively. Additionally, through a more thorough regression analysis, we find that in fact, larger banks in absolute terms achieve higher earnings according to their return on assets and return on equity. At the same time, the impact of systemic size on performance proved to be less clear, while the same can be said about the relationship between both size measures and the variable for bank risk, which was also ambiguous. Thus, the results concerning the measures of bank performance and stability are in line with the standpoint that bank systemic size is not a decisive factor to be considered by shareholders, given that it does not seem to provide any significant improvement in returns.

When it comes to their business models, it appears that systemically larger banks tend to concentrate on fee-generating activities and find a lower share of their short-term funding from deposits. As for large banks in absolute terms, they also seem to obtain a larger share of their income from non-interest-related activities but focus more on deposit funding, while holding relatively fewer loans and being better capitalized with less leverage. This suggests that, systemically larger banks have a less traditional structure and strategy than larger banks in absolute terms. One possible reason for this is that, large banks in absolute terms might have a tighter bond with national governments, meaning that they could face tougher regulations and control from policymakers in terms of areas of activity.

Lastly, regarding market discipline, some evidence illustrates the greater sensitivity of systemically larger banks' interest expenses to their capitalization. The higher sensitivity of funding costs to bank risk can be a sign of stricter market discipline and evidence of the “too-big-to-save” effect, where stakeholders perceive systemically large banks to be difficult to rescue in case of bankruptcy. On the other hand, the lack of market discipline was more apparent from the negative relationship between interest expense and both bank size measures (as well as the positive relationship between absolute size and deposit growth), proposing that a “too-big-to-fail” effect dominates most “too-big-to-save” considerations.

In the end, the evidence suggests that, in general, financial institutions in the European Union can benefit from a larger size both in absolute and relative terms. Results revealed modest awareness and few consequences for banks growing too large, as on the contrary, they seem to enjoy greater returns and less market discipline overall. Regarding the latter, we found

that disciplined endured through financing expenses does not stop banks from growing in both absolute and relative terms. Although there were some signs of change during the financial crisis, with falling systemic sizes on average and tougher market discipline to some extent, those trends seemed only temporary, with banks in general still ripping the benefits from the “too-big-to-fail” effect. Instead, governments and other decision-makers may need to implement harsher regulations in the future, if they determine that large banks represent a serious threat to the national economies.

In the future, it will thus be interesting to see if the trends identified in this study persist, if instead the “too-big-to-save” will become more apparent, or if policymakers will need to intervene directly to prevent other potential financial crises. Future research should also explore the possible benefits and costs of bank size on national economies and on financial markets, in order to gain further insights into the global consequences of the effects explored in our work. Such a study would be especially prominent now given the most recent events around the financial industry, namely the collapse of well-known global banks like Credit Suisse and Silicon Valley Bank, for which the full impact on local economies remains yet to be seen.

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## 7. Appendices

### 7.1. Appendix 1: Variable description and data sources

Variable	Definition	Sources
Assets	Log of assets in constant 2010 euros	Compustat Global
Liabilities	Log of liabilities in constant 2010 euros	Compustat Global
Gross income	Log of bank gross income in constant 2010 euros	Compustat Global
Liabilities over GDP	Bank liabilities divided by GDP	Compustat Global and WDI
Gross income over GDP	Bank gross income divided by GDP	Compustat Global and WDI
Return on assets	Pre-tax profits divided by assets	Compustat Global
Return on equity	Pre-tax profits divided by equity	Compustat Global
Z-score	Index of bank solvency constructed as $(ROA+CAR)/SROA$ , where ROA is return on assets, CAR is capital asset ratio, and SROA is the standard deviation of return on assets calculated for five consecutive 4-year periods	Compustat Global
Fee income	Share of non-interest income in total operating income	Compustat Global
Interest income	Net interest income divided by assets	Compustat Global
Other operating income	Other operating income divided by assets	Compustat Global
Loans	Total loans divided by earning assets	Compustat Global
Non-deposit short-term funding	Non-deposit short-term funding divided by deposits and other short-term funding	Compustat Global
Interest expense	Interest expense over bank liabilities excluding non-interest bearing debt	Compustat Global
Deposit growth	Growth rate of a bank's customer and short-term funding	Compustat Global
Equity	Ratio of equity to assets	Compustat Global
Liquidity	Ratio of liquid assets to customer and other short-term funding. Liquid assets include cash, government bonds, short-term claims on other banks (including certificates of deposit), and where appropriate the trading portfolio	Compustat Global
Overhead	Ratio of personnel and other non-interest expenses to assets	Compustat Global
Short-term debt	Bank's customer and short-term funding divided by total interest-bearing debt	Compustat Global
Investment bank	Dummy variable that equals 1 if bank is investment bank or securities firm, and zero otherwise	Compustat Global
Non-banking credit institution	Dummy variable that equals 1 if bank is non-banking credit institution, and zero otherwise	Compustat Global
Other bank	Dummy variable that equals 1 if bank is cooperative bank, Islamic bank, medium and long term credit bank, real estate and mortgage bank or savings bank, and zero otherwise	Compustat Global
Inflation	Consumer price inflation rate	WDI
GDP growth	Rate of real per capita GDP growth	WDI
GDP per capita	GDP per capita in thousands of constant 2010 euros	WDI

This table includes the definition and sources of the measures used to proxy for absolute and systemic bank size, bank performance, business model, market discipline, as well as additional control variables. These variables were constructed according to Bertay et al. (2013).

## 7.2. Appendix 2: Top 5 systemically large banks from 2009 to 2021

Bank	Country code	Liabilities over GDP	Assets
<b>Panel A: 2009</b>			
KOMERCNI BANKA AS	CZE	3.019	27.267
NORDEA BANK ABP	FIN	1.914	26.953
CYPRUS POPULAR BANK PCL	CYP	1.478	24.461
DEXIA SA	BEL	1.306	27.179
BNP PARIBAS FORTIS SA	BEL	0.990	26.930
<b>Panel B: 2010</b>			
SWEDBANK AB	SWE	3.535	28.244
KOMERCNI BANKA AS	CZE	2.979	27.268
NORDEA BANK ABP	FIN	2.314	27.121
CYPRUS POPULAR BANK PCL	CYP	1.535	24.491
DEXIA SA	BEL	1.245	27.134
<b>Panel C: 2011</b>			
SKANDIVISKA ENSKILDA BANK	SWE	3.520	28.382
SWEDBANK AB	SWE	3.115	28.265
KOMERCNI BANKA AS	CZE	2.931	27.350
NORDEA BANK ABP	FIN	2.504	27.297
BANK OF CYPRUS HOLDINGS PLC	CYP	1.403	24.454
<b>Panel D: 2012</b>			
SWEDBANK AB	SWE	3.373	28.307
KOMERCNI BANKA AS	CZE	3.304	27.379
NORDEA BANK ABP	FIN	2.646	27.290
CYPRUS POPULAR BANK PCL	CYP	1.244	24.185
HSBC HLDGS PLC	GBR	0.939	28.632
<b>Panel E: 2013</b>			
KOMERCNI BANKA AS	CZE	3.355	27.413
SWEDBANK AB	SWE	3.104	28.282
NORDEA BANK ABP	FIN	2.341	27.219
BANK OF CYPRUS HOLDINGS PLC	CYP	1.254	24.218
HSBC HLDGS PLC	GBR	0.910	28.633
<b>Panel F: 2014</b>			
SWEDBANK AB	SWE	3.443	28.383
NORDEA BANK ABP	FIN	2.327	27.230
JYSKE BANK	DNK	1.456	27.018
BANK OF CYPRUS HOLDINGS PLC	CYP	1.146	24.104
BANCO SANTANDER SA	ESP	0.858	27.867
<b>Panel G: 2015</b>			
NORDEA BANK ABP	FIN	2.973	27.311
JYSKE BANK	DNK	1.801	27.074
BANK OF CYPRUS HOLDINGS PLC	CYP	1.163	24.007
BANCO SANTANDER SA	ESP	1.060	27.946
BNP PARIBAS	FRA	0.941	28.503

<b>Panel H: 2016</b>			
NORDEA BANK ABP	FIN	2.685	27.239
JYSKE BANK	DNK	1.770	27.098
BANCO SANTANDER SA	ESP	1.007	27.926
SWISS NATIONAL BANK	CHE	0.962	27.339
BANK OF CYPRUS HOLDINGS PLC	CYP	0.930	23.845
<b>Panel I: 2017</b>			
NORDEA BANK ABP	FIN	2.422	27.201
JYSKE BANK	DNK	1.695	27.116
BANCO SANTANDER SA	ESP	1.035	28.015
SWISS NATIONAL BANK	CHE	1.016	27.461
BANK OF CYPRUS HOLDINGS PLC	CYP	0.914	23.884
<b>Panel J: 2018</b>			
NORDEA BANK ABP	FIN	1.992	27.087
JYSKE BANK	DNK	1.585	27.120
SWISS NATIONAL BANK	CHE	0.960	27.429
BANCO SANTANDER SA	ESP	0.951	28.009
HSBC HLDGS PLC	GBR	0.851	28.606
<b>Panel K: 2019</b>			
NORDEA BANK ABP	FIN	2.084	27.104
JYSKE BANK	DNK	1.810	27.219
BANCO SANTANDER SA	ESP	1.013	28.052
SWISS NATIONAL BANK	CHE	0.962	27.481
HSBC HLDGS PLC	GBR	0.883	28.630
<b>Panel L: 2020</b>			
NORDEA BANK ABP	FIN	2.092	27.121
JYSKE BANK	DNK	1.801	27.237
MONETA MONEY BANK AS	CZE	1.213	26.504
BANCO SANTANDER SA	ESP	1.160	28.084
SWISS NATIONAL BANK	CHE	1.102	27.630
<b>Panel M: 2021</b>			
NORDEA BANK ABP	FIN	1.944	27.144
JYSKE BANK	DNK	1.621	27.249
MONETA MONEY BANK AS	CZE	1.103	26.553
BANK OF GREECE	GRC	1.090	26.194
SWISS NATIONAL BANK	CHE	1.065	27.686

This table ranks the banks with the greatest liabilities-to-GDP ratio from 2009 to 2021. *Liabilities over GDP* stands for the bank's total liabilities divided by GDP, and *Assets* is the natural logarithm of total assets.