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Systemic risk in European banks: does ownership structure matter?

Nadia Saghi^{a1}, Zainab Srour^b, Jean-Laurent Viviani^a, Mohamad Jezzini^c

^a Université de Rennes, CNRS, CREM - UMR 6211, F-35000 Rennes, France

^b Rafik Hariri University Mechref, Liban

^c Université Libanaise, CNRS-L, Laboratoire des mathématiques, EDST, Liban

Abstract

We empirically test whether ownership concentration explains the cross-variation in systemic risk contribution for a sample of European banks over the 2004-2021 period and how this effect may vary depending on the category of the largest controlling shareholder. We explore two potential contagion channels: the risk-taking incentives and banks' assets commonality. The results show that higher ownership concentration is associated with greater banks' systemic risk contribution. Moreover, we find that banks' systemic risk contribution is even stronger for banks where institutional investors or States are the largest controlling owners. Overall, our findings contribute to the literature examining the determinants of banks' systemic risk in particular and financial stability as a whole and have several policy implications.

Keywords: European banking, ownership structure, systemic risk contribution

JEL Classification: *G21, G28, G32*

1. Introduction

The global financial crisis of 2008 highlights the inherently unstable nature of banking institutions and their incentives toward excessive risk taking, with a renewed debate on systemic fragility and macro-prudential regulation. As such, beyond re-examining systemic risk² assessment practices (e.g., Huang et al., 2012; Girardi and Tolga Ergün, 2013; Adrian and Brunnermeier, 2016; Brownlees and Engle, 2012, 2017; Acharya et al., 2017; Lin et al., 2018; Cerqueti et al., 2021), a growing strand of literature has investigated the factors behind the cross-sectional variation in banks' systemic risk and some works (e.g., Anginer et al., 2014; Weiß et al., 2014; De Jonghe et al., 2015; Jamshed et al., 2015; Laeven et al., 2016; Bakkar et al., 2019; Brunnermeier et al., 2020; Davydov et al., 2021; Addo et al., 2021) have specifically

¹ Corresponding author: nadia.saghi@univ-rennes.fr (N. Saghi-Zedek), Tel: +33223235091.

² A systemic event corresponds to a trigger point which causes significant disruption in the financial system and finally spreads out the real economy (Benoit, 2014).

examined the role played by environmental factors (regulation, network, competition) and financial institutions characteristics (e.g., size, diversification, profitability, capital structure, liquidity). Importantly, these papers perceive systemic risk as the correlation of banks' risk-taking and highlight the relevance to not only focus on the risk of individual financial institutions, but also on the individual bank's contribution to the risk of the financial system as a whole. While the literature on the measurement of systemic risk is amplified, studies on the determinants of financial institutions systemic risk exposure are only burgeoning. Despite the ongoing interest toward the driving factors of systemic risk exposure, surprisingly so far there are few studies that test whether corporate governance mechanisms of banks may be responsible on the correlation among banks' risk-taking (Jamshed et al., 2015). Actually, the banking industry is characterized by its strong integration and interconnectedness (Díez-Esteban et al., 2022), not only at a financial level but also at a governance one. This may result in complex networks of contractual, behavior and informational links that may amplify shocks. As a consequence, cross-sectional variations in systemic risk may relate to the risk correlations among financial institutions due to governance and specifically ownership linkages between them. Despite this evidence, there are very few studies that specifically test the effect of the ownership structure on banks' systemic risk. One notable exception is the one by Díez-Esteban et al. (2022). The objective of this paper is to fill this gap in the literature.

More precisely, in this paper we investigate the relationship between ownership structure and the systemic risk of banking institutions. Specifically, we look at the effect of ownership concentration on banks' systemic risk contribution and how this effect may vary depending on the category of controlling shareholders involved in banks' decision-making. Ownership structure is known to be a central element of banks decision-making and can affect banks' systemic risk through two important channels highlighted by the theoretical and empirical literature: (i) the risk-taking incentives channel (Acharya, 2009; Díez-Esteban et al., 2022) and (ii) the assets commonality channel (Wagner, 2010; Kartasheva, 2014; Yang et al., 2020; Duarte and Eisenbach 2021; Poledna et al. 2021). The first channel, referred to as the *risk-taking incentives*, is based on the statement that ownership structure is known to be the driving force behind the risk-taking incentives in nonfinancial firms in general and banks in particular (e.g., Jensen and Meckling, 1976; Galai and Masulis, 1976; Laeven and Levine, 2009). Controlling shareholders may encourage banks to take correlated risks, increasing their systemic contribution. Ownership structure can also affect banks' systemic contribution through the second channel, referred to as *assets commonality*. More precisely, controlling shareholders – especially of the same category – may have homogeneous behavior and objectives in terms of risk-taking and decision-making and, as a consequence, may encourage banks to take similar

and correlated risks as well as to engage in similar assets diversification. This herding behavior could lead to similar assets structure (i.e., assets commonality) among banks in the system. Assets commonality may be a source of a negative price contagion effect since the fire sales by one bank following a shock affect the value of all similar assets held by other banks. In this paper, we presume then that beyond affecting the individual risk of banks, ownership structure (i.e., ownership concentration and the category of shareholders) may be responsible for the correlation of banks' risk-taking behavior and their assets commonality at the aggregate level, affecting systemic risk contribution. Such an effect should be stronger/lower for some categories of controlling shareholders depending on their characteristics. Regardless of the contagion channel (*risk-taking incentives or assets commonality*), in this article, we assume that ownership structure can affect the systemic risk not only through the total risk taken by a financial institution at the individual level but also through specific contribution to systemic stability at the aggregate level.

Specifically, in this paper we use detailed ownership information on 114 publicly-listed banks based in 16 Western European countries³ over the 2004-2021 period to test the effect of ownership structure on banks' systemic risk contribution and how this effect might differ depending on the largest controlling shareholder category. More precisely, the objective of this paper is to test whether the risk-taking incentives of controlling owners at the individual level translate into higher systemic risk at the aggregate level through the risk-taking incentives and assets commonality channels.

We account for various factors and, consistent with our predictions, we find that higher ownership concentration leads to higher banks' systemic risk contribution as measured by the Delta Conditional Value at Risk (ΔCoVaR) and this relationship varies depending on the category of the bank's largest controlling shareholder. Specifically, we find that the effect of ownership concentration on systemic risk contribution is higher for banks controlled by other banking institutions, institutional investors or States. In addition, the effect of ownership structure on systemic risk contribution is enhanced for banks with higher levels of default risk (risk-taking incentives channel) and higher assets commonality (assets commonality channel). This result suggests that shareholders risk-taking incentives at the individual level lead to a herding behavior and greater correlated risk-taking at the aggregate level, making banks more

³ Since our objective is to test the effect of ownership concentration on systemic risk contribution, we focus on European countries where ownership is known to be more concentrated compared to other countries, for instance, the U.S. (La Porta et al., 1998). Additionally, European banks contribute more to global systemic risk than banks in the United States because of the lower quality of their loan portfolios and their higher relative interconnectedness with the financial system (Bostandzic and Weiß, 2018).

vulnerable to systemic shocks. Our results are robust to alternative measures of systemic risk including the marginal expected shortfall (MES) and the systemic risk index SRISK.

Our paper makes several contributions to the systemic risk and corporate governance literature. First, we build a bridge between the two strands of the literature by investigating the effect of ownership structure on banks' systemic risk contribution. Instead of focusing on systemic risk measurement (e.g., Brownlees and Engle, 2012, 2017; Adrian and Brunnermeier, 2016; Acharya et al., 2017), in this paper we rather examine differences in the systemic risk contribution. In doing so, we also contribute to the ongoing literature investigating the determinants of systemic risk (e.g., Brunnermeier et al., 2012; Anginer et al., 2014; De Jonghe et al., 2015; Acharya and Thakor, 2016) and introduce ownership structure as a new driving force behind systemic fragility. Furthermore, our paper contributes to the most recent studies on systemic fragility (e.g., Borri and Giorgio, 2021; Addo et al., 2021; Díez-Esteban et al., 2022) in several dimensions. Actually, in our study i) we consider not only the effect of ownership concentration on systemic risk contribution but also the effect of several shareholder categories (institutional investors, industrial companies, State and family shareholders), ii) we explore two important channels through which ownership structure could lead to higher systemic risk contribution: the risk-taking incentives channel and banks' assets commonality channel, iii) beyond the percentage of the largest shareholder, we use two other different proxies to measure ownership concentration including the percentage held by the most controlling shareholders as well as the Banzhaf Power Index (Leech, 2002) to take into account possible coalitions among the different controlling shareholders, iv) we use a larger sample with a longer period (2004-2021) including the 2008 global financial crisis, the sovereign debt crisis and the more recent Covid pandemic crisis. Our study further adds to the literature exploring the effect of ownership structure on banks risk-taking incentives (e.g., Laeven and Levine, 2009). Instead of focusing on the risk of individual financial institutions, we explore the role of ownership structure in explaining the individual bank's contribution to the risk of the financial system as a whole. We hence contribute to the recent debate on systemic fragility. Our study also contributes to the post-crisis debate on systemic fragility. Our findings support the regulatory perspective arguing that the contribution of an individual financial institution to the system's risk may be more relevant than the individual risk of that institution. Finally, our results also address the concerns of the Basel Committee on Banking Supervision (BIS, 2010) highlighting the importance of sound corporate governance schemes in the banking industry and requiring the disclosure of banks' ownership for further monitoring.

The remainder of the paper is structured as follows. In section 2, we discuss the relevant literature and develop the hypotheses. Section 3 describes the data, performs some univariate

analyses and defines the empirical model. In Section 4, we present the econometric results on the relation between systemic risk and ownership structure. Section 5 provides the robustness checks and Section 6 concludes the paper.

2. Related literature and hypotheses development

The theoretical and empirical literature highlights that banks' ownership characteristics (ownership concentration and type) may affect systemic risk through two different channels: (i) banks' risk-taking incentives, and (ii) assets commonality. The *risk-taking incentives* channel is based on the statement of Acharya (2009) indicating that "increasing a bank's risk increases the likelihood of a joint failure" and thus systemic risk. More precisely, Acharya (2009) points that excessive individual risk-taking incentives may increase the probability of a joint failure leading to higher systemic risk. The *assets commonality* channel refers to the common exposure among banks' assets portfolios mainly triggered by similar assets diversification. In other words, the commonality channel means that each bank seeks to diversify assets at the individual level but, if banks of the system choose similar assets to diversify, the risk at the system level will increase. More precisely, assets diversification at the individual bank level may amplify systemic risk as it increases the portfolio overlap between banks (Khandani and Lo, 2011). Because diversification not only reduces the probability of failure but also makes banks more similar to each other by exposing them to the same risks, it increases the systemic risk (Wagner, 2010; Yang et al., 2020). The financial system may become more fragile and vulnerable because the risk is reallocated (and not eliminated) across the system. In the same vein, Winton (1997) argues that pooling (diversification) elevates the joint failure risk. However, Acharya (2009) and Wagner (2011) make a fundamental difference between similar diversification (banks hold the same classes of assets and pursue similar activities, mainly named as assets commonality) and heterogeneous diversification where some banks invest in "exotic" classes of assets or develop new kind of activities. In the second case (i.e., heterogeneous diversification), the correlation between banks portfolios is smaller. Only the first kind of diversification (similar diversification) increases the bank's contribution to systemic risk and threatens the stability of the financial system (Goodhart and Wagner, 2012). Assets commonality (i.e., similar diversification) can be a consequence of unintentional decisions but financial institutions might also intentionally increase their common exposures when they jointly finance different projects—through syndicated loans (Cai et al. 2018; Kosenko and Michelson, 2022). Acharya (2009) shows conditions under which in equilibrium, banks prefer an inefficiently high correlation of assets returns, meaning that banks hold similar assets portfolios. Moreover, Acharya (2009) and Wagner (2011) show that the choice between similar and heterogeneous

diversified portfolios depends on the extra cost generated by banks simultaneous failure compared to individual ones as well as on the positive and negative externalities of bank failures. Previous studies show that the extent of banks' assets commonality has a positive impact on their systemic risk (Fricke, 2016) and generates the fire-sale spillover (Kartasheva, 2014; Duarte and Eisenbach 2021; Poledna et al. 2021) indicating that after a shock, some banks are going to fire sale assets leading to a decrease in assets price that will affect the balance sheet of other banks holding similar assets.

We explain below how ownership structure (ownership concentration and type) could affect systemic risk through the two above mentioned channels.

2.1. Ownership concentration and systemic risk

With regards to the risk-taking incentives channel, theory and evidence indicate a significant effect of ownership concentration on risk taking but without any consensus on the sign of such a relationship. That is, some studies (e.g., Shleifer and Vishny, 1986; Laeven and Levine, 2009) find that ownership concentration is associated with higher risk-taking, suggesting that banks with concentrated ownership (i.e., with at least one controlling owner) tend to be riskier than widely held banks (i.e., with no controlling shareholder), holding other factors constant. More precisely, in widely held banks, managers who are more likely to be involved in the decision-making process, have a concentrated wealth in their bank and should take less risk than diversified controlling owners. In contrast, some other studies find a negative relationship or even a U-shaped (or inverse U shape) relationship between ownership concentration and risk. For instance, in order to increase their private benefits (Burkart et al., 1997; Díez-Esteban et al., 2022) or due to convex incentives (DeYoung et al., 2013), in widely held banks, managers could encourage their institutions to take excessive risk. In the same context, some studies (Song and Li, 2012; Iannotta et al., 2007) find that higher ownership concentration is associated with lower insolvency and/or asset risk. This evidence suggests that the monitoring effect exerted by large shareholders could reduce managerial incentives to engage in risky activities (Díez-Esteban et al., 2022). In addition, an important feature of ownership concentration is that firms in general and banks in particular may belong to pyramidal business groups. The effect of ownership concentration on the risk-taking under pyramids is also not clear and may depend on the soundness of the banking industry. Indeed, during sound times, expropriation through the tunneling behavior -especially using related lending- is more likely to occur. In this case, entrenched controlling shareholders can divert resources from an affiliate firm where they have marginal financial interests to another where they hold substantial financial interests (Bertrand et al., 2002), leading to higher risk-taking and default risk (Saghi-Zedek and Tarazi, 2015).

During downturns, instead of extracting private benefits of control as they do during sound times (tunneling), controlling shareholders within pyramids could prop up their firms (i.e., transfer funds to the affiliate firms) to avoid their failure as they expect to extract valuable benefits in the future (Friedman et al., 2003; Khanna and Yafeh, 2005, 2007; Gopalan et al., 2007). This behavior is referred to as the propping up and could lead to lower default risk. In this context, Gopalan et al. (2007) empirically show that affiliate firms have lower probability of default than standalone ones. In contrast, Iqbal et al. (2015) show that banks with “good corporate governance mechanisms and shareholder-friendly boards of directors are positively associated with both balance-sheet and market-based measures of risk-taking”.

Ownership concentration could also affect banks systemic risk through the asset commonality channel. On the one hand, shareholders in widely-held banks are supposed to be more diversified and, as a consequence, banks should have less incentives to diversify their assets and should be subject to lower assets commonality. In this case, we expect higher ownership concentration to be associated with lower systemic risk. On the other hand, in widely-held banks, managers are the most involved in the decision-making process and should exhibit higher assets commonality for two reasons. First, because managers have their capital (human and financial) concentrated in one given bank, they should have more incentives to obtain diversification gains through individual banks’ assets diversification. Second, managers exhibit a herding behavior leading to higher asset commonality (Rajan, 1994; Addo et al., 2021). Managers herding may be due to two main factors: (i) bank managers often have the same financial culture, education and similar financial professional experience and, as a consequence, they use the same methodology to diversify their assets portfolios (Kosenko and Michelson, 2022); (ii) managers care about their reputation (Rajan 1994; Scharfstein and Stein 1990) and may for instance worry about getting a job in other banks and, as a consequence, they may engage in herding behavior because failing with others is more advantageous than failing alone.

The aforementioned discussion highlights that ownership concentration may affect risk-taking incentives at the individual level and assets commonality in two opposite directions. Those risk incentives taken at the individual level may result in a herding behavior and could directly translate into greater/lower systemic risk contribution of banking institutions depending on the prevailing effect. Under both channels (the risk-taking incentives and assets commonality), the net effect on systemic risk contribution is then theoretically ambiguous and worth to be investigated empirically. We then formulate the following hypothesis:

Hypothesis 1 (H1): Based on both above-mentioned channels, ownership concentration should affect banks systemic risk positively or negatively. This effect should be enhanced under higher risk-taking and higher assets commonality circumstances.

2.2. Ownership category and systemic risk

The category of controlling shareholders should affect systemic risk through both above-mentioned channels: i) the risk-taking incentives, and ii) banks' assets commonality.

Focusing on the first channel, risk-taking incentives may vary across different shareholder categories. Indeed, some categories of owners like managers, families and States (referred to thereafter as *un-diversified owners*) are not diversified and have their capital (human and financial) concentrated in one given firm/bank. In contrast, institutional investors, industrial companies and banking owners hold diversified portfolios (referred to thereafter as *diversified owners*). Differences in the extent of owners' portfolio diversification may affect their risk-taking incentives and strategies. Theory and evidence indicate that *diversified owners* are motivated to take more risk for higher expected returns whereas owners with less diversified portfolios take less risk to preserve their human capital skills and private benefits of control (e.g., Galai and Masulis, 1976; Saunders et al., 1990; Esty, 1998; Morck et al., 2000). Given these arguments, one could expect banks controlled by diversified owners to be riskier than their counterparts at the individual level and should contribute more to systemic fragility at the aggregate level, holding other factors constant (Shleifer and Vishny, 1986; Laeven and Levine, 2009). In this context, empirical studies on the global financial crisis show that institutional investors contributed to the crisis by pressuring the financial sector for short-term profits and increased risk-taking behavior (Manconi et al., 2012). It is the reason why Addo et al. (2021) assumes that there is a positive relationship between institutional ownership and bank systemic risk. However, empirical evidence is not clear cut on the effect of family ownership and risk-taking behavior. Actually, Maury (2006) shows that family ownership is negatively related to firm risk while Villalonga and Amit (2006) find that, contrary to theoretical expectation, family owned companies are less diversified and more risky (systemic and idiosyncratic risks) than non-family owned ones. In the same vein, there is no consensus on the effect of State ownership on the risk-taking incentives. On the one hand, State-owned banks, are more likely to be bailed out by their home governments when they encounter economic turbulence (Faccio et al., 2006) and should take lower risk and contribute less to systemic fragility. On the other hand, State-owned banks may benefit from implicit government insurance. More precisely, banks controlled by States might be considered by uninsured creditors as implicitly insured which should reduce the effectiveness of market discipline by reducing their incentives to monitor

them (Borisova and Megginson, 2011). In this context, Iannotta et al. (2007) confirm that public sector European banks have poorer loan quality and higher insolvency risk than other types of banks. From this point of view, one could expect State owned banks to contribute more to systemic fragility. Like other shareholder categories, the net effect of State ownership on systemic contribution is then ambiguous. Beyond the shareholder's portfolio diversification, the influence of each shareholder category on the bank risk-taking may also depend on its willingness to exercise its controlling power (Díez-Esteban et al., 2022). Indeed, passive shareholders will let the preeminence to managers to choose the bank risk level. Some categories of shareholders may adopt such a passive attitude when they have business and/or investment relations in the banks in which they are also owners (Chen et al., 2007; Ferreira and Matos, 2008; Bhattacharya and Graham, 2009). In contrast, some other categories like institutional investors may play an active role as shareholders (Erkens et al., 2012; García-Gómez et al., 2014). Active controlling shareholders can reduce the total costs of monitoring by giving the institution easier access to management and the board (Cornett et al., 2007). Banks with active (passive) large shareholders could be associated with less (high) individual risk and, as a consequence, less (high) systemic contribution, in line with the hypothesis that they monitor insiders more (less) actively (e.g., Cornett et al., 2007; Chen et al., 2007).

Focusing on the second channel, the extent of decision-makers (managers/controlling shareholders) portfolio diversification may itself explain the extent and the nature of banks' portfolio diversification. Unlike *diversified owners*, less diversified ones may seek for assets diversification at the bank level to compensate the under diversification at the investor level. From this regard, banks controlled by less diversified owners should contribute more to systemic risk compared to their counterparts. However, for non-diversified owners, the extra cost of common failure and negative externalities of failure (impact of a bank failure on economic activities) should prevent to invest in similar portfolios to avoid assets commonality. For diversified owners, positive externality should be taken into account: if we invest in bank A and B, the cost of bank A failure could be compensated by the increase of activity and profitability of bank B generated by the failure of A. For instance, managers taking into account the difficulties to find a new job in case of simultaneous bank failure, should choose non-correlated bank assets. Taking into consideration the nature of assets portfolio diversification beyond the extent of diversification, we expect banks controlled by less diversified owners to contribute less to systemic risk compared to their counterparts. In addition, even among diversified owners, one could observe different levels of banks' assets commonality. Banks and institutional investors as controlling owners are faced with incentive structure based on performance comparison with peers, together with their limited liability (Blei and Ergashev,

2014; Acharya and Yorulmazer, 2005; 2007) and, as a consequence, may have mimetic behavior leading to higher assets commonality. In contrast, for industrial owners, we expect a lower degree of assets commonality. Indeed, even if their performance is also assessed via comparison, as the comparison benchmark (their specific industry) is different than the bank industry one, they should be less affected by herding behavior.

Given these arguments based on both contagion channels, the net effect of ownership type on systemic risk contribution is difficult to assess theoretically and worth to be investigated empirically. We then test the following hypothesis:

Hypothesis 2 (H2): The effect of ownership concentration on banks systemic contribution should be different among shareholder categories. Such an effect should be enhanced under higher risk-taking and higher assets commonality circumstances.

3. Data, variables, statistics and model specification

Before presenting the empirical findings and results, we describe the sample, the variables, the sample characteristics as well as the model specification.

3.1. Sample selection

Our study spans the 2004-2021 period and focuses on publicly traded banks based in 16 Western European countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Norway, Netherlands, Portugal, Sweden, Spain, Switzerland and the United Kingdom.⁴

Our ownership data come from Orbis⁵ database while accounting and market data used in this study come primarily from the Bloomberg database. Regulatory variables' data come from the Bank Regulation and Supervision Surveys conducted in the World Bank. We primarily use consolidated statements when available; otherwise we use unconsolidated statements. All banks in the sample report annual financial statements following an accounting period from January 1st to December 31st.

For the time period and countries covered by our study, we identify 154 publicly listed banks for which the Orbis database provides detailed information on banks' ownership structure. We then collect for these banks information on balance sheets and income statements from the Bloomberg database. We also obtain weekly market data necessary to compute systemic risk indicators from the Bloomberg database. We eliminate observations for which Bloomberg does

⁴ We do not include Luxembourg within the set of Western European countries because no bank provides ownership data consistent with the criteria we use to define our cleaned sample.

⁵ We have used an advanced online version of the Orbis dataset including the package "Orbis Historical" and providing access to historical data going back 15-20 years.

not provide information on financial and market variables of interest as well as banks with discontinuously traded stocks. We remove the outliers of the main financial variables when it seems necessary to minimize their effect. We then end up with a final sample of 114 banks corresponding to 1796 year-observations (see Tables 1 and 2 for a breakdown of the sample by country and year). Based on the Bloomberg classification, our sample includes mostly commercial banks (90%) and diversified banking institutions (10%).

3.2. Variables definition

In this paper, we question whether ownership structure affects banks' systemic risk contribution through two channels: (i) the risk-taking incentives, and (ii) banks' assets commonality. To achieve that, we first define the dependent variable reflecting banks' systemic risk. Then, we define our independent variable of interest (ownership structure). Finally, we describe the set of control variables introduced in our regressions. Descriptive statistics and other details on all variables used in our regressions are reported in Table 3.

3.2.1. Measuring banks' systemic risk

In accordance with the aim of this paper which is to investigate the effect of ownership structure on banks' systemic risk contribution, we mainly use the Delta Conditional Value at Risk (ΔCoVaR)— as initially proposed by Adrian and Brunnermeier (2016) — for each bank in our sample. For robustness analyses, we use different proxies of the ΔCoVaR and two other alternative systemic risk measures including the Marginal Expected Shortfall (MES) [Acharya et al., 2017] and the systemic risk index SRISK (Brownlees and Engle, 2017).

Our main dependent variable in our empirical analysis is then the ΔCoVaR .⁶ In our setting, the system's CoVaR is the VaR (Value at Risk) of the financial system if a particular institution is under financial distress.⁷ We measure the contribution of each bank to the system's risk using the ΔCoVaR defined as the difference between the VaR of the system when a particular institution i becomes financially stressed (i.e., at the q^{th} percentile) and the VaR of the system when the institution is at its median (i.e., 50% percentile). ΔCoVaR is computed at $q=1\%$ for each bank for the 2004-2021 period, and at $q=5\%$ for robustness considerations. ΔCoVaR measures each bank contribution to the system's risk. To ease the interpretation of the results, we use the absolute value of ΔCoVaR meaning that higher values of ΔCoVaR indicating higher systemic risk contribution. The annual ΔCoVaR for each bank is calculated as the mean of the

⁶ Details on the computation of the ΔCoVaR as well as the MES and SRISK are provided in the Online Appendix A.

⁷ In our empirical framework, we define the financial system as the set of all banks in the sample.

weekly ΔCoVaRs of each year.⁸ For robustness considerations, we also compute: i) the annual $\Delta\text{CoVaR}_{\text{med}}$ as the median value of weekly ΔCoVaRs of each year, and ii) the annual $\Delta\text{CoVaR}_{\text{rolling}}$ as the mean of two-year rolling windows ΔCoVaRs .

3.2.2. Ownership structure measures and characteristics

In this paper, we aim to investigate the effect of ownership structure on banks' contribution to systemic risk through the risk-taking incentives and banks' assets commonality channels.

To measure ownership concentration, we collect from Orbis information on all direct shareholders as well as ultimate owners for each bank included in the sample for the period 2004–2021. In our analysis, we focus on direct ownership and do not consider ultimate ownership. It would be interesting to go deeper and investigate indirect ownership. However, indirect ownership links and mainly cross-holdings do not prevail in publicly listed banks.⁹ Those complex links are mainly present in privately owned banks which are not included in our sample because we need market data to mainly calculate systemic risk indicators (Lepetit et al., 2015; Saghi-Zedek and Tarazi, 2015). To analyze direct ownership, we follow previous studies on both banking institutions (Caprio et al., 2007; Laeven and Levine, 2009) and nonfinancial firms (La Porta et al., 1999; Laeven and Levine, 2008) and set a control threshold of 10% assuming that it provides a significant portion of votes to exert effective control and influence banks' decision-making. Based on this threshold, we consider a bank as controlled if it has at least one shareholder with 10% or more of shares and, as widely-held if it has no controlling shareholder. For robustness considerations, we also consider higher (20% and 25%) but also lower (5%) control thresholds (e.g., Azofra and Santamaría, 2011; Saghi-Zedek, 2016).

In our empirical analysis, we use two indicators to capture banks' ownership concentration. The first measure, denoted thereafter as Concentration1, is the percentage of shares held by the largest controlling shareholder. The second measure is the Banzhaf Power Index (Leech, 2002) denoted thereafter as BPI.¹⁰ The BPI takes into consideration the possible coalitions among the largest shareholders (i.e., the possibility to unite with other shareholders to make decisions in a bank). The BPI measures the relative controlling power of each shareholder among the bank's largest controlling shareholders. More precisely, the BPI of a shareholder in a given bank provides the fraction of the winning coalitions in which the shareholder is present among the

⁸ Similarly, Adrian and Brunnermeier (2016) calculate quarterly values of ΔCoVaR by averaging the weekly observations within each quarter of the period. Our results -not reported in the paper but available on request- remain unchanged.

⁹ The analysis of ownership data indicates that most of the control chains of our sample banks are composed of only one level. In 90% of the cases, for a control threshold of 25%, the ultimate owner provided by Orbis coincides with the largest controlling shareholder.

¹⁰ We calculate the BPI using the algorithms for voting power analysis developed by Leech (2002) at the University of Warwick. More details on the definition and computation of this index are reported in the Online Appendix A.

total number of winning coalitions.¹¹ In both cases, ownership concentration is set equal to zero if the bank is widely held (i.e., banks with no controlling shareholder).

In line with the aim of our analysis, beyond ownership concentration we also consider the type of the largest controlling shareholder of each bank. We hence classify banks' controlling shareholders into five categories: banks (Bank); institutional investors including insurance companies, mutual and pension funds, and financial companies (Investor);¹² industrial companies (Industry); individuals or family investors (Family); and States or public authorities (State). Based on these categories, we define five variables (Bank, Investor, Industry, Family, and State) that report the proportion of ownership held by the largest shareholder if it is of that category, and zero otherwise.¹³

We present in Table 4 information on ownership type and the percentage held by each shareholder category. Considering the control threshold of 10%, our sample includes controlled banks (around 64% of the observations) and widely-held banks (36% of the observations). The number of direct controlling shareholders for each bank ranges from one to eight. The data also show that industrial companies, other banking institutions and institutional investors are the predominant largest controlling shareholders of banks in our sample. Family and State owners are also present as largest controlling shareholders but at a lower extent compared to other categories.¹⁴

3.2.3. Control variables

We include in our estimations a set of bank-specific and country-level control variables that are expected to affect banks' systemic risk contribution.

The Basel Committee on Banking Supervision argued that systemically important banks can be identified using a number of attributes like size, lack of substitutability, interconnectedness, diversification and complexity. As bank level variables, we then include in the model a set of variables that reflect these attributes and that were identified by previous studies¹⁵ as affecting banks' systemic risk contribution. Specifically, we include in our regressions the following variables: the natural logarithm of bank total assets (LnTA) as a proxy for bank size as well as the square term of LnTA (LnTA2) to take into account potential non-linearity effects of bank

¹¹ A coalition is considered as winning if it allows to obtain the pre-fixed power (i.e., the minimum threshold). In our setting, we have computed the BPI for three different thresholds: 50%, 30% and 20%.

¹² Banks are also institutional investors. We follow previous studies and separate banks from other institutional investors to investigate potential differences in their behavior (see among others Saghi-Zedek and Tarazi, 2015 and Saghi-Zedek, 2016).

¹³ Unlike other studies on ownership structure (e.g., Caprio et al., 2007; Laeven and Levine, 2008; Saghi-Zedek and Tarazi, 2015), in our sample no bank is classified as controlled by a foundation/research institute.

¹⁴ Details on the distribution of ownership structure across countries and years are reported in the Online Appendix B (Tables B1-B4).

¹⁵ See for example Brunnermeier et al., 2012 Anginer et al., 2014a; Anginer et al., 2014; Mayordomo et al., 2014; De Jonghe et al., 2015; Jamshed et al., 2015; Laeven et al., 2016; Bostandzic and Weiß, 2018; Elyasiani and Jia, 2019; and Borri and Giorgio, 2021.

size on systemic risk contribution; the ratio of equity to total assets (EQTA) to account for banks' capitalization; the ratio of net income to total assets (ROA) to account for differences in the level of bank profitability and its ability to efficiently generate profits throughout the business cycle; the ratio of net loans to total assets (LOTA) as a proxy for differences in banks' business models, complexity and liquidity; the ratio of loan loss provisions to net loans (LLP) to account for differences in credit risk among banks and the quality of their loan portfolio; and the market to book ratio (MTB) defined as the market value of equity divided by the book value of equity to account for banks' growth opportunities. In line with the objective of our study, we include two binary variables: (i) the binary variable $d(\text{ZScore})$ ¹⁶ measuring the individual bank default risk level is used to capture the risk-taking incentives contagion channel; (ii) the binary variable $d(\text{AssetCommonality})$ ¹⁷ capturing the extent of interconnections and the risk of contagion among banks is used to proxy banks' assets commonality contagion channel, it takes a value of one if the AssetCommonality variable is higher than the median value and, zero otherwise.

Regarding country level variables, we introduce a vector of regulatory variables (Regulation) characterizing the design of the regulatory regimes implemented in the sample banks' home countries (Anginer et al., 2014). Specifically, we include the deposit insurance schemes index (DIS) to take into account the effect of the generosity of deposit insurance schemes on the risk-taking incentives of shareholders in banks (Demirgüç-Kunt and Detragiache, 2002; Barth et al., 2004)¹⁸; the capital stringency index (CAP) to consider the effect of capital requirements on the banking system (Barth et al., 2004, Berger and Bouwman, 2013);¹⁹ and the assets diversification index (DIV) to account for differences in asset diversification across banks (Winton, 1997, Acharya, 2009; Wagner, 2011). Beyond these regulatory variables, we also include the growth rate of the real gross domestic product (GDPGrowth) to take into account differences in the macroeconomic environment within countries as well as the ratio of the market share of the three largest banks in each country (MarketShare) as a proxy for the banking system concentration (Anginer et al., 2014).

¹⁶ The variable ZScore is calculated as follows: $ZScore = \frac{ROA+EQTA}{SDROA}$, where SDROA is the standard deviation of ROA computed on a rolling-window of three years ($t - 2, t$). Lower values of ZScore indicate a higher probability of failure. $d(\text{ZScore})$ is a dummy variable taking a value of one if ZScore is lower than the median value, and zero otherwise.

¹⁷ Higher values of the variable AssetCommonality indicate higher banks' assets correlation. Details on the computation of banks' assets commonality are provided in the Online Appendix A.

¹⁸ While various papers include the existence of an explicit deposit insurance scheme and the coverage ratio in their studies (e.g., Anginer et al., 2014; Weiß et al., 2014), we do not include these two variables in our analysis since all banks of the sample present an explicit deposit insurance schemes and there is no significant variety among the deposit insurance coverage ratio.

¹⁹ The capital stringency index (CAP) used in this study captures the overall as well as the initial capital stringency. The overall capital stringency measures the extent of regulatory requirements regarding the amount of capital banks must hold. The initial capital stringency measures whether the source of funds that count as regulatory capital can include assets other than cash or government securities, borrowed funds, and whether the regulatory/supervisory authorities verify the sources of capital. The capital stringency index incorporates the previous two measures of capital stringency (Barth et al., 2004).

3.3. Ownership structure and banks' characteristics: univariate analysis

We analyze the characteristics of the sample banks depending on their ownership concentration. To achieve this, we divide the sample banks into two groups based on the median value of the ownership concentration measure (Concentration1).²⁰ Banks with high (low) ownership concentration are banks for which the ownership concentration variable is above (below) the median value.

Table 5 compares the key financial characteristics and systemic risk contribution of concentrated and dispersed banks. In terms of general financial characteristics, the results do not display significant differences across concentrated and dispersed banks. Specifically, the data show that banks with high ownership concentration are better capitalized and have greater growth opportunities compared to banks with dispersed ownership. Regarding systemic risk contribution (Panel B of Table 5), the table mainly shows that banks with concentrated ownership are associated with higher systemic risk contribution (higher values of ΔCoVaR in absolute value) suggesting that ownership concentration increases banks' systemic risk contribution. This result is consistent with the predictions suggesting that controlling owners – especially if they are of the same category – may encourage their banks to take similar risky activities increasing the correlation of their risk-taking behavior and making them simultaneously vulnerable to shocks.

To better emphasize the characteristics of the sample banks, we further analyze the data across sound times and distress times, i.e. the financial crisis (2008-2009), the European sovereign debt crisis (2010-2012), and the Covid19 pandemic crisis (2020-2021). Not surprisingly, the data (Table 6) show that systemic contribution of our banks has increased during the crisis times [i.e., financial crisis of 2008-2009, the sovereign debt crisis 2010-2012, and the Covid19 pandemic crisis 2020-2021]. The results also show that banks become less profitable (lower ROA) and have lower growth opportunities during the three crisis periods. Moreover, the table indicates that banks have increased their provisions (higher LLP) during the financial crisis and the sovereign debt crisis.

To analyze the pattern of our systemic risk measure (ΔCoVaR), we report in Table 7 the average systemic contribution by country. The table shows that systemic risk contribution is higher for banks located in countries like Greece and Ireland. The table also shows enough

²⁰ We also use the BPI variable to divide the sample into two groups and we find similar conclusions as for the variable Concentration 1 (see Table 5 for the obtained results).

heterogeneity in the data allowing us to investigate the link between ownership structure and banks' systemic risk contribution.

3.4. Model specification

Our first objective is to test whether ownership concentration affects systemic risk and whether such an effect is enhanced under higher levels of risk-taking incentives and assets commonality (H1). For this purpose, we follow previous studies [e.g., Borri et al. (2012); Borri and Giorgio (2021); Díez-Esteban et al. (2022)] and estimate the following dynamic model including year dummies (Year):

$$\begin{aligned}
 \text{SystemicRisk}_{it} &= [\alpha_1 + \beta' \times d(\text{Channel})] \times \text{OwnershipConcentration}_{it} \\
 &+ \lambda \text{SystemicRisk}_{it-1} + \varphi'X + \sum_{j=1}^3 \rho_j \times \text{Regulation}_{it}^j + \alpha_0 \\
 &+ \sum_{t=2005}^{2021} \omega_t \text{Year}_i^t + \varepsilon_{it}
 \end{aligned} \tag{1}$$

The dependent variable in Eq.(1) is the systemic risk contribution measured by the absolute value of ΔCoVaR for bank i at time t . $d(\text{channel})$ is a vector including the binary variables $d(\text{ZScore})$ capturing the risk-taking incentives contagion channel and $d(\text{AssetCommonality})$ used as a proxy for banks' assets commonality contagion channel. $\text{OwnershipConcentration}$ refers to one of the ownership measures described above (Concentration1 or BPI). X is a vector of bank and country level control variables as defined above and including: LnTA , LnTA2 , EQTA , ROA , LOTA , LLP , MTB , $d(\text{ZScore})$, $d(\text{AssetCommonality})$, GDPGrowth and MarketShare .²¹ Regulation is the vector of regulatory variables: DIS , CAP and DIV .

The coefficient α_1 measures the effect of greater ownership concentration on banks' systemic risk contribution. The coefficient β_j associated to the interaction term $d(\text{Channel}) \times \text{OwnershipConcentration}_{it}$ measures to what extent the effect of ownership concentration on banks' systemic risk contribution is different depending on the two contagion channels (i.e., the risk-taking incentives channel and banks' assets commonality). Because ownership concentration could affect banks' systemic risk in two opposite directions under both channels according to the statement of the first hypothesis (H1), the sign of the coefficient α_1 is

²¹ Table B.5 in the Online Appendix B shows the correlation coefficients among the main independent variables used in our regressions. On the whole, the correlation coefficients are low except for bank size as measured by the natural logarithm of total assets (LnTA) and the ratio of equity to total assets (EQTA). We introduce separately LnTA and EQTA in the regressions and the results are not affected by high correlation. We hence include both variables in the same regression.

ambiguous and should depend on the prevailing effect. The coefficient β_j should be statistically significant and have the same sign as α_1 to be consistent with H1.

Our second objective is to test whether the effect of ownership concentration on banks' systemic contribution is different among various shareholder categories; that is to test the second hypothesis (H2). Given the arguments based on both contagion channels, we expect the relationship between ownership concentration and systemic risk to be different among categories of shareholders. To test this hypothesis (H2), we estimate the following model as specified in Eq.(2):

$$\begin{aligned}
 \text{SystemicRISK}_{it} &= \left[\sum_{j=1}^5 (\alpha_j + \beta_j \times d(\text{Channel})) \right] \times \text{OwnershipType}_{it}^j \\
 &+ \lambda \text{SystemicRisk}_{it-1} + \varphi'X + \sum_{j=1}^3 \rho_j * \text{Regulation}_{it}^j + \alpha_0 \\
 &+ \sum_{t=2005}^{2021} \omega_t \text{Year}_i^t + \varepsilon_{it}
 \end{aligned} \tag{2}$$

$\text{OwnershipType}_{it}^j$ is a set of variables reporting the percentage of shares held by the largest shareholder if it is of that category, and zero otherwise as previously defined (Bank, Investor; Family, State, and Industry).

4. Econometric results

The objective of this section is to examine the effect of ownership structure (i.e., ownership concentration and type) on European banks' systemic risk contribution.

We estimate the coefficients of the dynamic panel model presented in Eq. (1) and Eq. (2) using the Blundell and Bond (1998) Generalized Method of Moments (GMM). We check the validity of the GMM instruments (lagged values of the dependent variable and all the ownership variables) using the Hansen test (a test of exogeneity of all instruments as a group) and the Arellano and Bond test for the absence of second order residual autocorrelation (AR2 test).

Tables 8 and 9 report respectively the estimation results of both models as presented in equations Eq.(1) and Eq.(2). Columns 1-2 of Table 8 report the results using the two proxies of ownership concentration (Concentration1 and BPI) for the first contagion channel that is the risk-taking incentives channel [as measured by the variable $d(\text{ZScore})$] and columns 3-4 present the estimation results for the second contagion channel that is banks' asset commonality measured by the binary variable $d(\text{AssetCommonality})$.

The results of Table 8 (H1) show that ownership concentration is associated with higher systemic contribution and this result holds in all the regressions regardless of the ownership measure we use: the coefficient α_1 associated to the ownership concentration variable is positive and statistically significant in all the regressions whatever the ownership measure we use (Concentration 1 or BPI). These results suggest that the prevailing effect is positive, indicating that controlling owners may have homogeneous behavior and objectives in terms of risk-taking and push their banks to behave similarly and take correlated risk, increasing their systemic contribution. In addition, consistent with the first hypothesis (H1) the results of Table 8 show that the effect of ownership concentration on systemic contribution is enhanced for higher levels of default risk and higher levels of banks' asset commonality. More precisely, the coefficient β_1 associated to the interaction term $d(\text{Channel}) \times \text{OwnershipConcentration}_{it}$ is positive and statistically significant in all regressions, suggesting that -as expected- the two discussed channels (risk-taking incentives and banks' assets commonality) strengthen the effect of ownership concentration on banks' systemic contribution (Wald tests are displayed at the bottom of Table 8). Our results are then consistent with the first hypothesis and suggest that ownership concentration exposes banks to similar sources of credit or any other risk and results in a herding behavior and greater correlated risk taking, making the banking system more fragile to shocks.

Consistent with the predictions of the second hypothesis (H2), the results of Table 9 show that the effect of ownership concentration on systemic contribution is enhanced when the controlling shareholder is another banking institution, an institutional investor or a State and this holds for both channels: the coefficient β_j associated to the interaction term involving the binary variable $d(\text{Channel})$ and the proportion of ownership held by these shareholder categories [$\text{OwnershipType}_{it}^j$] is positive and statistically significant, suggesting that these categories of shareholders strengthen the banks' systemic contribution through the risk-taking incentives and assets commonality channels (Wald tests are displayed at the bottom of Table 9).

Regarding control variables our results are on the whole consistent with prior studies. More specifically, the findings show that better capitalized banks (EQTA), more profitable banks (ROA) and banks with higher growth opportunities (MTB) contribute less to systemic risk. However, banks with higher levels of default/credit risk [$d(\text{ZScore})$, LLP] and higher levels of assets commonality [$d(\text{AssetCommonality})$] contribute more to systemic risk. The results also indicate that banking systems with a higher market share (MarketShare) are more contributing to the overall risk compared to their counterparts. Regulatory variables also affect banks'

systemic risk. Specifically, we find that banks located in countries with more deposit insurance schemes (DIS) are associated with higher systemic contribution, consistent with the moral hazard behavior that may arise from the generosity of deposit insurance schemes. Also, banks located in countries supporting geographical assets diversification (DIV) contribute more to the fragility of the banking system. However, the results suggest that stringent capital requirements (CAP) reduce banks' systemic risk contribution. The remaining control variables are generally statistically non-significant.

On the whole, our results are consistent with both the risk-taking incentives and banks' assets commonality channels indicating that shareholder-controlled banks should be subject to similar risk-taking behavior and, as a consequence, ownership concentration leads to a common individual risk exposure through both channels, making the banking sector vulnerable to systemic shocks. Our results also show that ownership concentration has a stronger impact on banks' systemic risk contribution if those banks are controlled by other banks, institutional investors or States.

5. Robustness checks

In this section, we perform various regressions to check the robustness of our previously obtained results. We test if our results are robust during different time periods and by using alternative measures of systemic risk and ownership structure. The results are reported in the Online Appendix C.

Our sample period includes sound and distress times. To ensure that our results are not affected by the financial crisis of 2008-2009, the European debt crisis of 2010-2012 and the Covid19 pandemic crisis of 2020-2021, we run regressions separately on subsamples of normal times and distress times. In all cases, our results remain unchanged (see panels A-C of Table C.1).

Besides performing regressions during various periods, we test the robustness of our results using alternative measures of systemic risk. Until now, the annual ΔCoVaR we use in our analyses is measured as the mean value of weekly ΔCoVaRs . To check whether the use of the mean value has not biased our results, we compute the annual ΔCoVaR as: i) the median value of weekly ΔCoVaRs ($\Delta\text{CoVaR}_{\text{med}}$), ii) the 2-year rolling average of weekly ΔCoVaRs ($\Delta\text{CoVaR}_{\text{rolling}}$). In both cases, our results remain unchanged (see Panels A and B of Table C.2). We also estimate our systemic risk measure -the ΔCoVaR - at the 95% level (ΔCoVaR_{95}) instead of 99% level as previously done. The results are still the same (see Table C.3). In

addition to this test, we also capture banks' systemic risk using two other measures: the marginal expected shortfall (MES) and the systemic risk index (SRISK), both computed at 99% level. The results (Panels A and B of Table C.4) show that our conclusions are the same across these two alternative systemic risk measures.²²

Additionally, we also test the sensitivity of our results to the definition of ownership variables. First, we change the control threshold and compute again ownership variables with a control level of 25% and 5% instead of 10%. The control threshold of 25% (5%) increases (decreases) the proportion of banks considered as widely held and decreases (increases) the proportion of family- and State-owned banks in our sample.²³ Nevertheless, our main results are unchanged (see panels A and B of Table C.5). Second, we measure ownership concentration using the percentage held by the bank's global ultimate owner instead of the direct largest controlling shareholder as previously done.²⁴ The results reported in Table C.6 provide similar conclusions.

Finally, to account for the global country effect (regulatory and macroprudential), we run the regressions by substituting the regulatory variables (DIS, CAP and DIV) with country dummies; binary variables that indicate the bank's country. Our main results still hold (see Table C.7).

6. Conclusion

The aim of this study is to empirically test the impact of ownership structure on banks' systemic risk through two main channels: the risk-taking incentives channel and banks' assets commonality channel. More specifically, we investigate whether banks' systemic contribution depends on their ownership concentration and test how this effect may vary across different shareholders categories. For this purpose, we construct a dataset on ownership concentration and accounting and market data of 114 banks based in 16 European countries during the 2004-2021 period. We estimate systemic risk using the ΔCoVaR which measures the contribution of each bank to the overall risk. Then we define ownership structure indicators that capture the controlling shareholder ownership percentages and types. Finally, we establish a link between systemic risk and ownership structure by running panel regressions.

Our results show that ownership concentration is associated with greater systemic contribution through the risk-taking incentives and assets commonality channels, suggesting

²² Our results -not tabulated- also hold for MES and SRISK calculated at the 95% level.

²³ We also perform a robustness check using a control threshold of 20%. The main conclusions remain similar.

²⁴ Orbis database provides information of the global ultimate owner of each bank for a control threshold of 25%.

that the presence of controlling shareholders leads banks to take highly correlated risks making them more vulnerable. A deeper analysis shows that such a relationship is even stronger for banks where institutional investors and States are the largest controlling owners.

On the whole, our findings contribute to the post-crisis debate on systemic fragility. Our paper supports the regulatory perspective arguing that the contribution of an individual financial institution to the system's risk may be more relevant than the individual risk of that institution. Our results also address the concerns of the Basel Committee on Banking Supervision (BIS, 2010) highlighting the importance of sound corporate governance schemes in the banking industry and requiring the disclosure of banks' ownership for further monitoring.

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Table 1

Distribution of European banks by country

This table shows the number banks and observations in the final sample by country.

Country	Number of sample banks	Number of observations
Austria	2	39
Belgium	2	36
Denmark	15	248
Finland	3	35
France	15	264
Germany	4	65
Greece	3	63
Ireland	3	19
Italy	10	169
Netherlands	1	18
Norway	27	385
Portugal	1	18
Spain	5	89
Sweden	3	56
Switzerland	10	150
United Kingdom	10	142
Total	114	1796

Table 2

Distribution of observations by year

This table shows the number of observations in the final sample by year from 2004 to 2021.

Year	Number of observations	Percentage of observations
2004	70	3.90
2005	76	4.23
2006	76	4.23

2007	86	4.79
2008	89	4.96
2009	92	5.12
2010	96	5.35
2011	93	5.18
2012	91	5.07
2013	97	5.40
2014	97	5.40
2015	103	5.73
2016	110	6.12
2017	117	6.51
2018	121	6.74
2019	127	7.07
2020	126	7.02
2021	129	7.18
Total	1796	100

Table 3

Variables definition and summary statistics

This table provides the definition and summary statistics for all the variables used in our regressions. The sample consists of 114 European banks corresponding to 1796 year observations during the 2004-2021 period.

Variable name	Definition	Source	Mean	Median	Standard deviation	Minimum	Maximum	NB observations
<i>Systemic risk variable</i>								
ΔCoVaR	Mean of weekly ΔCoVaRs defined as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median (50% percentile) (%).	Bloomberg/ authors calculation	0.828	0.620	0.878	0.01	8.851	1796
<i>Ownership structure variables</i>								
Concentration 1	The percentage of shares held by the largest controlling shareholder (%). Concentration1 is equal to zero when the bank is widely held.	Orbis	23.072	16.000	26.146	0	100	1796
BPI	The Banzhaf Power Index	Orbis	0.285	0	0.424	0	1	1796

	computed at 30% threshold. Details on the computation of this index are provided in the Online Appendix A.							
Bank	The percentage of shares held by the largest controlling shareholder if it is a bank; and zero otherwise (%).	Orbis	31.377	25.000	22.421	10	100	1796
Investor	The percentage of shares held by the largest controlling shareholder if it is a financial company, an insurance company, a mutual or a pension fund; and zero otherwise (%).	Orbis	25.401	21.300	15.560	10	95.200	1796
Family	The percentage of shares held by the largest controlling shareholder if it is an individual or a family; and zero otherwise (%).	Orbis	35.180	30.975	23.769	10	100	1796
State	The percentage of shares held by the largest controlling shareholder if it is a State, a government or a public authority; and zero otherwise (%).	Orbis	67.273	64.230	19.180	10.300	100	1796
Industry	The percentage of shares held by the largest controlling shareholder if it is an industrial company; and zero otherwise (%).	Orbis	34.792	27.250	22.746	10	100	1796
<i>Bank characteristics</i>								
LnTA	Natural logarithm of total assets (Millions of Euros).	Bloom berg	9.904	9.765	2.518	4.650	14.784	1796

EQTA	Ratio of total equity to total assets (%).	Bloom berg	9.402	7.646	8.569	1.139	94.067	1796
ROA	Return on assets defined as the ratio of net income to total assets (%).	Bloom berg	0.630	0.599	1.014	-7.170	6.917	1796
LOTA	Ratio of net loans to total assets (%).	Bloom berg	66.570	71.695	19.481	0.110	93.585	1796
LLP	Loan loss provisions defined as the amount of loan loss provisions divided by net loans (%).	Bloom berg	0.382	0.170	0.665	-0.976	7.757	1796
MTB	Market to book defined as the ratio of the market value of equity to the book value of equity (%).	Bloom berg	83.729	60.938	74.157	0.323	547.369	1796
ZScore	A measure of bank default risk computed as Zscore = (ROA+EQTA)/SDROA, where SDROA is the 3-year rolling window standard deviation of ROA.	Bloom berg	103.059	59.598	124.190	-1.413	596.373	1796
AssetCommonality	A measure of the extent of banks' assets similarity (%). Details on the definition of AssetCommonality are provided in the Online Appendix A.	Bloom berg/ authors calculation	64.944	67.835	11.340	20.494	83.528	1796
<i>Country variables</i>								
GDPGrowth	Growth rate of real GDP (Gross Domestic Product) (%).	Bloom berg	1.310	1.600	2.797	-12.800	25.800	1796
MarketShare	The ratio of the market share of the three largest banks in each country (%).	Bloom berg	77.411	84.262	21.844	3.009	99.960	1796
<i>Regulatory variables</i>								
DIS	Deposit insurance schemes index. All countries of our sample present explicit deposit insurance schemes. We use the deposit insurance scheme database of 2003 for years 2004-2009, the survey of 2010 for years	Asli Demirgüç-Kunt et al.,(2014)	4.886	5.000	1.245	1.000	7.000	1796

Table 4

Ownership characteristics of the sample banks

This table reports information on ownership type for the sample banks. We differentiate banks according to the type of their owners: a bank (Bank); a financial company, an insurance company, a mutual or a pension fund (Investor); an individual or a family (Family); a State, a government or a public authority (State); an industrial company (Industry). Widely Held refers to banks with no controlling shareholder.

Owner type	Percentage of observations	Number of observations	Number of banks	Percentage of ownership
Bank	17.820	320	19	31.377
Investor	14.870	267	22	25.401
Family	4.790	86	5	35.180
State	8.800	158	11	67.273
Industry	17.540	315	23	34.792
Widely Held	36.180	650	34	0

Table 5

Financial characteristics, systemic risk and ownership concentration: univariate analysis

This table compares the financial characteristics of banks depending on their ownership concentration over the 2004-2021 period. Using a control threshold of 10%, we classify a bank with a high ownership concentration (low ownership concentration) if the percentage held by the largest shareholder is greater (lower) than the median value. $d(\text{Concentration1})$ is a dummy equal to one if Concentration1 is greater than its median, and zero otherwise; Concentration1 is the percentage of shares held by the largest controlling shareholder. LnTA is the natural logarithm of total assets; EQTA is the ratio of total equity to total assets; ROA is the ratio of net income to total assets; LOTA is the ratio of net loans to total assets; LLP is the amount of loan loss provisions divided by net loans; MTB is the ratio of the market value of equity to the book value of equity; ΔCoVaR is the absolute value of the mean of the weekly ΔCoVaRs defined as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median;. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

Variable	Banks with high ownership concentration [$d(\text{Concentration1})=1$]	Banks with low ownership concentration [$d(\text{Concentration1})=0$]	T-statistics
Panel A: General financial characteristics			
LnTA	9.931	9.891	0.3145
EQTA	10.906	8.698	5.1252***
ROA	0.614	0.638	-0.4681
LOTA	67.115	66.315	0.8110
LLP	0.359	0.393	-0.9973
MTB	97.526	77.265	5.4396***
Panel B: Systemic risk			
ΔCoVaR	0.885	0.800	1.9226**

Table 6

Characteristics of sample banks during normal and distress times

This table compares the characteristics of banks during several periods. We split the sample into four groups: (1) normal times (2004-2007; 2013-2019); (2) the financial crisis period (2008-2009); (3) the sovereign debt crisis (2010-2012); and (4) the covid19 crisis. ΔCoVaR is the absolute value of the mean of the weekly ΔCoVaRs defined as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median; LnTA is the natural logarithm of total assets; EQTA is the ratio of total equity to total assets; ROA is the ratio of net income to total assets; LOTA is the ratio of net loans to total assets; LLP is the amount of loan loss provisions divided by net loans; MTB is the ratio of the market value of equity to the book value of equity. T-statistics are based on the difference between each crisis period and normal times. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

	(1)	(2)	(3)	(4)			
Variable	Normal times: 2004-2007,	Financial crisis: 2008-	T- statistics	Sovereign debt crisis:	T-statistics (3)-(1)	Covid19 crisis: 2020-2021	T- statistics
ΔCoVaR	0.778	1.257	7.0685**	0.957	4.4076***	0.826	1.8829*
LnTA	9.924	9.724	-1.0148	10.008	0.7726	10.032	0.8992
EQTA	9.514	8.410	-1.6435	8.487	-2.0567**	9.934	0.4206
ROA	0.653	0.425	-2.8860**	0.258	-7.5338***	0.583	-2.8693***
LOTA	66.440	67.733	-0.8464	66.348	-0.4628	64.364	-1.9104*
LLP	0.367	0.520	2.9532**	0.571	5.5317***	0.310	-0.3686
MTB	85.128	71.248	-2.3910**	64.943	-5.9041***	65.086	-5.6373***

Table 7

Banks' systemic risk by country

This table presents the average of systemic risk contribution as measured by the ΔCoVaR in each country. ΔCoVaR is the absolute value of the mean of the weekly ΔCoVaRs defined as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median.

Country	ΔCoVaR
Austria	1.026
Belgium	1.077
Denmark	0.787
Finland	0.555
France	0.612
Germany	0.900
Greece	2.441
Ireland	1.343
Italy	0.924
Netherlands	0.826
Norway	0.715
Portugal	1.162
Spain	0.761
Sweden	0.827
Switzerland	0.415
United Kingdom	1.033

Table 8

Ownership concentration and banks' systemic risk

This table reports the estimation results of the model presented in Eq.(1) for the sample of 114 banks over the 2004-2021 period. The dependent variable is the absolute value of ΔCoVaR defined as the mean of weekly ΔCoVaRs calculated as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median. Our variable of interest is the OwnershipConcentration defined as follow: (1) Concentration1 is the percentage of shares held by the largest controlling shareholder, (2) BPI is the Banzhaf Power Index that measures the relative controlling power of each shareholder among the bank's largest controlling shareholders (details on its definition and computation are provided in the Online Appendix A). The risk-taking incentives and assets commonality channels are respectively measured using the d(ZScore) and d(AssetCommonality) variables: d(ZScore) is a dummy variable taking a value of one if the variable ZScore is lower than the median value, and zero otherwise; d(AssetCommonality) is a dummy variable taking a value of one if the AssetCommonality variable is higher than the median value, and zero otherwise (details on the definition of AssetCommonality are provided in the Online Appendix A). The four models are performed on the sample of 114 banks of 1796 observations. LnTA is the natural logarithm of total assets; LnTA2 is the squared term of LnTA; EQTA is the ratio of total equity to total assets; ROA is the ratio of net income to total assets; LOTA is the ratio of net loans to total assets; LLP the amount of loan loss provisions divided by net loans; MTB is the ratio of the market value of equity to the book value of equity; GDPGrowth is the real GDP (Gross Domestic Product) growth rate; MarketShare is the ratio of the market share of the three largest banks in each country; DIS is the deposit insurance schemes index; CAP is the capital stringency index; DIV is the asset diversification index. Hansen test is a test of exogeneity of all instruments as a group. AR2 test is a test of the absence of second order residual autocorrelation. P-Values (reported in parentheses) are based on robust standard errors. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

d(Channel) Ownership measure	(1)	(2)	(3)	(4)
	d(ZScore)		d(AssetCommonality)	
	Concentration1	BPI	Concentration1	BPI
OwnershipConcentration (α_1)	0.0036*** (0.0000)	0.2886*** (0.0000)	0.0056*** (0.0000)	0.3290*** (0.0000)
d(Channel)*OwnershipConcentration (β_1)	0.0042*** (0.0000)	0.2215*** (0.0002)	0.0008* (0.0878)	0.1345* (0.0671)
d(AssetCommonality)	0.0029* (0.0851)	0.0211** (0.0161)	0.0051* (0.0835)	0.0014* (0.0963)
d(ZScore)	0.0828*** (0.0000)	0.1133*** (0.0000)	0.1634*** (0.0000)	0.1681*** (0.0000)
Lagged dependent variable	0.0129* (0.0912)	0.0144* (0.0531)	0.0044* (0.0672)	0.0104* (0.0741)
LnTA	0.0477 (0.4575)	0.0670 (0.1850)	0.0020 (0.9718)	0.0343 (0.2978)
LnTA2	0.0053 (0.1819)	-0.0004 (0.8836)	0.0030 (0.2585)	0.0014 (0.4231)
EQTA	-0.0010* (0.0824)	-0.0004* (0.0784)	-0.0009* (0.0843)	-0.0022* (0.0979)
ROA	-0.0535*** (0.0000)	-0.0454*** (0.0000)	-0.0454*** (0.0000)	-0.0514*** (0.0000)
LOTA	0.0007 (0.2850)	0.0011 (0.1687)	0.0008 (0.2688)	0.0015* (0.0541)
LLP	0.1972*** (0.0000)	0.2099*** (0.0000)	0.2117*** (0.0000)	0.2169*** (0.0000)
MTB	-0.0012*** (0.0000)	-0.0012*** (0.0000)	-0.0012*** (0.0000)	-0.0011*** (0.0000)
GDPGrowth	-0.0047 (0.2053)	-0.0047 (0.2637)	-0.0051 (0.1580)	0.0006 (0.8868)
MarketShare	0.1018*** (0.0000)	0.0891*** (0.0000)	0.1016*** (0.0000)	0.0892*** (0.0000)
DIS	0.0295*** (0.0031)	0.0552*** (0.0000)	0.0499*** (0.0000)	0.0647*** (0.0000)
DIV	0.1130*** (0.0000)	0.0649*** (0.0000)	0.1091*** (0.0000)	0.0716*** (0.0000)
CAP	-0.0207** (0.0226)	-0.0230*** (0.0016)	-0.0228*** (0.0098)	-0.0274*** (0.0002)
Intercept	1.0067** (0.0315)	0.1798 (0.6163)	0.6183 (0.1446)	0.2224 (0.2040)
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.2000	0.1999	0.1998	0.1999
AR2 test (P-value)	0.1495	0.1839	0.1768	0.2060

Wald tests: $\alpha_1 + \beta_1$	0.0078*** (0.0000)	0.5101*** (0.0000)	0.0064*** (0.0000)	0.4635*** (0.0000)
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Table 9

Ownership concentration and bank systemic risk: the impact of the largest controlling shareholder category

This table reports the estimation results of the model presented in Eq.(2) for the sample of 114 banks over the 2004-2021 period. The dependent variable is the absolute value of ΔCoVaR of each bank defined as the mean of weekly ΔCoVaRs calculated as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median. Bank, Investor; Family, State, and Industry is a set of variables reporting the percentage of shares held by the largest shareholder if it is of that category, and zero otherwise. The risk-taking incentives and assets commonality channels are respectively measured using the $d(\text{ZScore})$ and $d(\text{AssetCommonality})$ variables: $d(\text{ZScore})$ is a dummy variable taking a value of one if the variable ZScore is lower than the median value, and zero otherwise; $d(\text{AssetCommonality})$ is a dummy variable taking a value of one if the Asset Commonality variable is higher than the median value, and zero otherwise. Bank level variables is a vector of control variables including: Lagged dependent variable, LnTA, LnTA2, EQTA, ROA, LOTA, LLP, MTB, $d(\text{ZScore})$ and $d(\text{AssetCommonality})$. Country level variables is a vector of control variables at the country level including: GDPGrowth, MarketShare, DIS, CAP and DIV. The definition of all these variables is provided in Table3. *Hansen test* is a test of exogeneity of all instruments as a group. *AR2 test* is a test of the absence of second order residual autocorrelation. P-Values based on robust standard errors are reported in parentheses. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

	(1)	(2)
d(Channel)	d(ZScore)	d(AssetCommonality)
Bank (α_1)	0.0031** (0.0139)	0.0036** (0.0114)
d(Channel) *Bank (β_1)	0.0010* (0.0595)	0.0017** (0.0400)
Investor (α_2)	0.0008* (0.0935)	0.0190*** (0.0000)
d(Channel)* Investor (β_2)	0.0179*** (0.0000)	0.0146*** (0.0000)
Family (α_3)	0.0001 (0.9379)	-0.0064 (0.4814)
d(Channel) *Family (β_3)	0.0017 (0.1110)	0.0115 (0.2079)
State (α_4)	0.0044** (0.0430)	0.0031** (0.0357)
d(Channel) * State (β_4)	0.0003 (0.8889)	0.0001 (0.1208)
Industry (α_5)	0.0007 (0.2027)	0.0009 (0.3938)
d(Channel) *Industry (β_5)	0.0002 (0.8005)	-0.0001 (0.9424)
Bank level variables	Yes	Yes
Country level variables	Yes	Yes
Year dummies	Yes	Yes
Number of observations	1796	1796
Number of banks	114	114
Hansen test (P-value)	0.5559	0.6513
AR2 test (P-value)	0.6002	0.5837
Wald tests: Bank ($\alpha_1 + \beta_1$)	0.0041** (0.0312)	0.0053** (0.0435)
Institutional ($\alpha_2 + \beta_2$)	0.0187***	0.0336***

	(0.0000)	(0.0030)
Family ($\alpha_3 + \beta_3$)	0.0018	0.0051
	(0.1205)	(0.1307)
State ($\alpha_4 + \beta_4$)	0.0047**	0.0032**
	(0.0131)	(0.0432)
Industry ($\alpha_5 + \beta_5$)	0.0009	0.0008
	(0.7910)	(0.8625)

Appendix A

This Appendix provides details on the calculation of systemic risk measures. More precisely, it explains the use of quantile regressions as well as the calculation of alternative systemic risk measures.

1. Calculating systemic risk measures

This subsection provides more details on the calculation of the main systemic risk measure (ΔCoVaR) as well as on the two alternative systemic risk measures used in the robustness analyses: the Marginal Expected Shortfall (MES) and the Systemic risk index (SRISK).

1.1. The Delta Conditional Value at Risk (ΔCoVaR)

To compute the ΔCoVaR , we use quantile regressions. In this subsection, we explain (i) the use of quantile regressions and (ii) the calculation of the ΔCoVaR .

1.1.1. Quantile regressions

Koenker (2005) presents a detailed description about the general quantile regressions.

While OLS regression models the relationship between a set of independent variables (X_i) $_{i=1,\dots,n}$ and the conditional mean of the dependent variable Y , quantile regression estimates the conditional quantiles of the independent variable Y given certain values of (X_i). Quantile regression can be viewed as an extension of linear regression; it allows for a more complete picture of the conditional distribution of Y given (X_i) when one is interested in the lower or upper quantile. Particularly, in finance, quantile regression is useful to estimate the Value at Risk (VaR) and risk measures where the lowest 1% or 5% quantiles are of interest.

Suppose that the returns X_t^i have the following linear factor structure:

$$X_{t+1}^j = \phi_0 + \phi_1 M_t + \phi_2 X_{t+1}^i + (\phi_3 + \phi_4 M_t) \Delta Z_{t+1}^j$$

where M_t is a vector of State variables; ΔZ_{t+1}^j is the error term assumed to be i.i.d. with zero mean and unit variance and $E[\Delta Z_{t+1}^j | M_{t-1}, X_{t+1}^i] = 0$. The conditional expected return is given

by $\mu^j[X_{t+1}^j | M_t, X_{t+1}^i] = \phi_0 + \phi_1 M_t + \phi_2 X_{t+1}^i$ and the conditional volatility is given by $\sigma_t^{jj}[X_{t+1}^j | M_t, X_{t+1}^i] = (\phi_3 + \phi_4 M_t)$. Instead of estimating the coefficients $\phi_0, \phi_1, \phi_2, \phi_3$ and ϕ_4 using OLS regression that requires a distributional assumption, quantile regressions are used to estimate these coefficients for different percentiles.

Let F be the cumulative distribution function of the error term ΔZ^j with the inverse distribution function $F_{\Delta Z^j}^{-1}(q)$ for the q -quantile.

We can immediately obtain the inverse distribution function of X_{t+1}^j :

$$F_{X_{t+1}^j}^{-1}(q | M_t, X_{t+1}^i) = \alpha_q + \gamma_q M_t + \beta_q X_{t+1}^i$$

where $\alpha_q = \phi_0 + \phi_3 F_{\Delta Z^j}^{-1}(q)$, $\gamma_q = \phi_1 + \phi_4 F_{\Delta Z^j}^{-1}(q)$ and $\beta_q = \phi_2$ for $q \in (0, 1)$.

$F_{X_{t+1}^j}^{-1}(q | M_t, X_{t+1}^i)$ is referred to as the conditional quantile function.

VaR is then obtained by solving the following equation:

$$\text{VaR}_{q,t+1}^j = \inf_{\text{VaR}_{q,t+1}^j} \{ \Pr(X_{t+1}^j | \{M_t, X_{t+1}^i\} \leq \text{VaR}_{q,t+1}^j) \geq q \} = F_{X_{t+1}^j}^{-1}(q | M_t, X_{t+1}^i)$$

By conditioning on $X_{t+1}^i = \text{VaR}_{q,t+1}^i$ we obtain the CoVaR_{t+1}^{ji} using the quantile function:

$$\begin{aligned} \text{CoVaR}_{q,t+1}^{ji} &= \inf_{\text{VaR}_{q,t+1}^j} \{ \Pr(X_{t+1}^j | \{M_t, X_{t+1}^i = \text{VaR}_{q,t+1}^i\} \leq \text{VaR}_{q,t+1}^j) \geq q \} \\ &= F_{X_{t+1}^j}^{-1}(q | M_t, X_{t+1}^i = \text{VaR}_{q,t+1}^i) \end{aligned}$$

The quantile function is estimated by predicting the q -quantile regressions of X_{t+1}^i on M_t and X_{t+1}^j by solving

$$\min_{\alpha_q, \beta_q, \gamma_q} \sum_t \begin{cases} q |X_{t+1}^j - \alpha_q - \beta_q X_{t+1}^i - \gamma_q M_t| & \text{if } (X_{t+1}^j - \alpha_q - \beta_q X_{t+1}^i - \gamma_q M_{t-1}) \geq 0 \\ (1-q) |X_{t+1}^j - \alpha_q - \beta_q X_{t+1}^i - \gamma_q M_t| & \text{if } (X_{t+1}^j - \alpha_q - \beta_q X_{t+1}^i - \gamma_q M_{t-1}) < 0 \end{cases}$$

Adrian and Brunnermeier (2016) provide detailed discussion about quantile regression properties.

1.1.2. Calculating the ΔCoVaR

To estimate CoVaR , we collect from the Bloomberg database weekly data as used in Adrian and Brunnermeier (2016). We then run the following quantile (as explained above) regressions including a vector of State variables (M_{t-1}):

$$\begin{cases} X_t^i = \alpha_q^i + \gamma_q^i * M_{t-1} + \varepsilon_{q,t}^i \\ X_t^{s|i} = \alpha_q^{s|i} + \beta_q^{s|i} * X_t^i + \gamma_q^{s|i} * M_{t-1} + \varepsilon_{q,t}^{s|i} \end{cases} \quad (1)$$

where X_t^i is the return²⁵ of the institution i at time t ; M_{t-1} is a vector of lagged State variables including: volatility index (V2X) which captures the implied volatility in the stock market, liquidity spread which is the difference between the three-month repo rate and the three-month bill rate, the change in the three-month bill rate, the change in the slope of the yield curve which is the difference between German ten-year government bond yield and the German three-month Bublic rate, the change in credit spread measured by the spread between ten-year Moody's seasoned BAA-rated corporate bond, and finally the German ten-year government bond and the S&P 500 return index as a proxy for market equity returns (Anginer et al., 2014a; Adrian and Brunnermeier, 2016); $X_t^{s|i}$ is the return of the system s conditional on the return of the bank i at time t ; and ε_t^i and $\varepsilon_{q,t}^{s|i}$ are the error terms.

We then use the predicted values from the regression as specified in Eq.(1) to obtain:

$$\begin{cases} \text{VaR}_{q,t}^i = \hat{\alpha}_q^i + \hat{\gamma}_q^{s|i} * M_{t-1} \\ \text{CoVaR}_{q,t}^{s|i} = \hat{\alpha}_q^{s|i} + \hat{\beta}_q^{s|i} * \text{VaR}_{q,t}^i + \hat{\gamma}_q^{s|i} * M_{t-1} \end{cases} \quad (2)$$

where $\text{VaR}_{q,t}^i$ is the VaR of the institution i at time t ; and $\text{CoVaR}_{q,t}^{s|i}$ is the VaR of the system s conditional on the distress situation of the institution i (i.e., when it is at its $\text{VaR}_{q,t}^i$) at time t . Finally, we measure the contribution of each bank to the system's risk using the ΔCoVaR defined as the difference between the VaR of the system when a particular institution i becomes financially stressed (i.e., at the q^{th} percentile) and the VaR of the system when the institution is at its median (i.e., 50% percentile). Formally, the ΔCoVaR is expressed as follows:

$$\Delta\text{CoVaR}_{q,t}^{s|i} = \text{CoVaR}_{q,t}^{s|i} - \text{CoVaR}_{0.5,t}^{s|i} \quad (3)$$

1.2. Marginal Expected Shortfall (MES)

As defined by Acharya et al. (2017), the Marginal Expected Shortfall (MES) is the mean return during times of a market crash. Formally, the MES of bank i at time t is given by the following equation:

²⁵ In our study, we define the return as $\ln(\frac{P_t^i}{P_{t-1}^i})$, where P_t^i is the price of stock i at time t .

$$\text{MES}_{i,t}(q) = E_{t-1}[R_{i,t} | R_{m,t} < \text{VaR}_{m,t}(q)] \quad (1)$$

where $R_{i,t}$ denotes the weekly stock returns²⁶ of bank i at time t , $R_{m,t}$ is the return at time t of the market m , i.e. the system which is defined as the set of all banks in the sample. $\text{VaR}_{m,t}(q)$ denotes the q Value-at-Risk of the market m at time t , which is the maximum value so that the probability of the loss that exceeds this value equals to q .

Since we do not have the return indices for all countries, we construct the market weighted return and we exclude the bank for which the MES is calculated from the banking sector.

By setting $q=5\%$ and 1% , we compute $\text{MES}_{i,t}(5\%)$ and $\text{MES}_{i,t}(1\%)$ that corresponds respectively to the expected loss of the bank i conditional on the market experiencing its 5% and 1% of the worst days. Finally, we define the annual systemic risk exposure as the mean of weekly MES, and for robustness as the median of weekly MES. Higher values of MES (in absolute value) indicate higher systemic risk exposure.

1.3. The systemic risk index (SRISK)

Following Brownlees and Engle (2017), we estimate the SRISK index which measures the expected capital shortage faced by a financial institution during a period of system distress when the market declines substantially.

SRISK is estimated based on the above-mentioned Marginal Expected Shortfall (MES). We first use the MES to obtain the Long Run Marginal Expected Shortfall (LRMES) as follows:

$$\text{LRMES}_{i,t} = 1 - \exp(-18 \times \text{MES}_{i,t}) \quad (1)$$

where i denotes the bank and t the time period.

Then, based on LRMES, we calculate SRISK as follows:

$$\text{SRISK}_{i,t} = k \times \text{Debt}_{i,t} - (1 - k)(1 - \text{LRMES}_{i,t})\text{Equity}_{i,t} \quad (2)$$

where k is the minimum fraction of capital (expressed as a ratio of equity to total assets) each bank needs to hold, and $\text{Debt}_{i,t}$ and $\text{Equity}_{i,t}$ are the book value of its debt (total liabilities) and the market value (market capitalization) of its equity, respectively. We set k equal to the prudential capital ratio of 8%.

²⁶ In our study, we define the return as $\ln\left(\frac{P_t^i}{P_{t-1}^i}\right)$, where P_t^i is the price of the stock i at time t .

2. Banzhaf Power Index (BPI)

This subsection provides a short and non-technical explanation of the meaning and computation of the Banzhaf Power Index (BPI) based on the Leech (2002) paper. The question is how to measure the power of each member in a weighted voting system (such as a joint stock company)? In the context of companies, the classical answer is that the power of a given shareholder depends on its relative number of shares. Power analysis first proposes a definition of power in this context, second it shows the weaknesses of the percentage of voting rights as a measure of power and third, proposes more relevant measures of power.

Following Leech (2002) “a member's power rests on how often he or she can add his or her votes to those of a losing coalition so that it wins.” In short, power indexes measure one member ability to swing a decision. With this definition in mind, it is easy to illustrate the weakness of the “percentage of shareholders” measure. Suppose three different shareholders with 49%, 49% and 2% of shares. As any two shareholders are required to obtain the 50% majority, the 2% shareholder has exactly the same power as the two other 49% shareholders.

The main idea of the Banzhaf Index to measure the power of one given shareholder is to compute the relative number of times that a given shareholder can influence the decision by transferring his or her voting weight to a coalition which is losing without him/her but wins with him/her. Leech (2002) presents several ways to compute the index. The simplest one is the direct enumeration method that consists in computing the index directly from its definition presented above. The main drawback of this approach is its exponential time complexity when the number of controlling shareholders increases. As we consider only up to eight major shareholders, the method can be used easily in our case. The method contains three main steps:

In the first step, we enumerate all the possible coalitions among the 8 largest shareholders that lead to a significant power in the company. We use three different quotas (i.e., minimum percentage of voting rights that leads to a significant power): 50%, 30% and 20%. Coalitions that reach the quota are considered as the winning coalitions.

In the second step, we compute the number of times a given shareholder is an essential member of the coalition. A member is essential if when he/she is removed from the coalition, the latter cannot obtain the quota (that is the main idea that the coalition is winning with the member and loosing without it).

In the third and final step, we count the total number of coalitions where one shareholder is essential. The BPI of one given shareholder is then defined as the ratio of the number of coalitions where this given shareholder is essential divided by the total number of coalitions where one shareholder is essential.

3. Calculating banks' assets commonality

This appendix describes the methodology we follow to compute the assets commonality for the sample banks.

The *assets commonality* refers to the common exposure among banks' assets portfolios mainly triggered by similar assets diversification. We follow Dissem (2019) to compute the assets commonality between European banks for the 2004-2021 period as initially developed by Cai et.al (2018).

First, to capture the commonality between assets, we calculate the distance between each two institutions, m and n using the Euclidean distance as follows:

$$\text{distance}_{m,n,t} = \sqrt{\sum_{j=1}^J (X_{m,j,t} - X_{n,j,t})^2} \quad \text{with } m \neq n \quad (1)$$

Where $X_{k,j,t}$ is the exposure to sector j of bank k normalized by the bank total exposure. In other words, it is the weight of the Exposure at Default (EAD) of each category j of the asset class relatively to total EAD of the bank k . In our sample, we classify the assets into eight classes ($J=8$): fixed assets, long term marketable securities, commercial loans, consumer loans, other loans, cash and near cash items, short term marketable securities, and interbank assets.

Noting that, for each bank m , we have the following: $\sum_{j=1}^J X_{m,j,t} = 1$.

The smaller the distance between two banks is, the more the portfolios are similarly allocated and hence exposed to the same type of risk.

Second, we calculate the weight of each bank n at time t as follows:

$$W_{n,t} = \frac{\text{total assets}_{n,t}}{\text{sum of total assets}_t} \quad (2)$$

Finally, we compute the assets commonality for each bank m at time t of asset classes as follows:

$$\text{asset commonality}_{m,t} = \left(1 - \frac{\sum_{m \neq n} W_{n,t} \cdot \text{distance}_{m,n,t}}{\sqrt{2}}\right) \times 100 \quad (3)$$

where $\text{distance}_{m,n,t}$ is the distance between bank m and bank n at time t as defined in (1), and $W_{n,t}$ is the weight given to bank n as calculated in (2). The assets commonality measure is

normalized to a scale of 0-100 with 0 being the least interconnected and 100 being the most interconnected.

Appendix B

This appendix reports details on the ownership structure of the sample banks as well as the correlations among the main explanatory variables.

Table B.1

Ownership concentration per year and shareholder category

This table reports the ownership concentration distribution per year and per shareholder category.

We differentiate banks according to the type of their owners: a bank (Bank); a financial company, an insurance company, a mutual or a pension fund (Investor); an individual or a family (Family); a State, a government or a public authority (State); an industrial company (Industry).

Year	Bank	Investor	Family	State	Industry	Average
2004	29.931	21.500	42.477	65.743	41.196	37.069
2005	30.865	24.905	35.735	63.437	33.741	37.132
2006	34.737	17.120	35.377	63.466	44.278	37.813
2007	33.962	19.300	42.279	69.377	22.244	35.096
2008	26.632	23.519	34.711	70.437	33.010	34.705
2009	30.942	23.648	30.320	59.540	33.420	34.109
2010	32.241	20.150	27.602	62.509	40.998	34.979
2011	34.936	24.957	29.938	64.533	40.516	38.686
2012	32.257	29.372	32.107	69.994	38.571	37.957
2013	31.762	41.492	23.973	74.251	32.954	39.072
2014	29.174	31.744	29.157	65.794	27.198	33.308
2015	30.521	29.906	64.952	70.456	31.412	38.570
2016	25.616	27.105	44.216	71.668	39.700	37.397
2017	32.334	26.642	56.090	68.994	39.790	37.938
2018	34.584	22.589	28.090	68.230	34.351	35.001
2019	35.268	24.480	21.735	68.388	32.922	35.378
2020	30.773	23.088	31.030	63.419	34.766	34.310
2021	33.016	23.592	38.783	68.221	30.684	34.140
Average	31.377	25.401	35.180	67.273	34.792	36.158

Table B.2

Ownership breakdown per year and shareholder category

This table reports the distribution of the number of observations per year and per shareholder category.

We differentiate banks according to the type of their owners: a bank (Bank); a financial company, an insurance company, a mutual or a pension fund (Investor); an individual or a family (Family); a State, a government or a public authority (State); an industrial company (Industry). Widely Held refers to banks with no controlling shareholder.

Year	Bank	Investor	Family	State	Industry	Widely Held	Total
2004	14	7	3	6	5	35	70
2005	13	6	4	7	7	39	76
2006	14	8	4	7	6	37	76
2007	16	9	8	6	8	39	86
2008	16	9	9	7	12	36	89
2009	19	13	7	9	9	35	92
2010	20	12	6	7	14	37	96
2011	22	8	5	8	16	34	93
2012	19	12	4	7	17	32	91
2013	21	13	6	9	17	31	97
2014	25	14	3	8	20	27	97
2015	26	13	5	10	18	31	103

2016	26	12	5	10	23	34	110
2017	15	29	1	11	28	33	117
2018	14	26	3	11	25	42	121
2019	13	24	4	12	32	42	127
2020	11	27	6	12	27	43	126
2021	16	25	3	11	31	43	129
Total	320	267	86	158	315	650	1796

Table B.3

Ownership concentration per country and shareholder category

This table reports the breakdown of ownership concentration by country and shareholder category.

We differentiate banks according to the type of their owners: a bank (Bank); a financial company, an insurance company, a mutual or a pension fund (Institutional); an individual or a family (Family); a State, a government or a public authority (State); an industrial company (Industry).

Country	Bank	Investor	Family	State	Industry	Average
Austria	54.320	35.090	24.323	-	56.751	42.026
Belgium	26.824	-	-	-	56.770	44.292
Denmark	23.902	17.276	16.351	75.000	23.421	22.204
Finland	100.000	19.587	100.000	19.867	26.270	44.685
France	26.101	24.295	17.973	13.650	51.264	27.432
Germany	17.469	17.107	26.882	23.287	24.957	21.476
Greece	43.350	35.173	-	-	37.900	36.081
Ireland	-	28.243	-	71.690	99.990	63.132
Italy	73.400	45.323	39.319	66.642	21.570	46.954
Netherlands	33.077	-	49.950	-	-	35.327
Norway	21.693	16.756	10.000	-	41.620	32.389
Portugal	-	-	-	-	18.898	18.898
Spain	34.115	17.584	-	-	51.000	28.724
Sweden	-	20.533	-	-	19.293	19.458
Switzerland	10.800	-	-	70.047	70.025	69.155
United Kingdom	18.457	30.136	53.039	62.400	18.310	34.783
Average	31.377	25.401	35.180	67.273	34.792	36.158

Table B.4

Ownership breakdown per country and shareholder category

This table reports the distribution of the number of observations per country and shareholder category.

We differentiate banks according to the type of their owners: a bank (Bank); a financial company, an insurance company, a mutual or a pension fund (Investor); an individual or a family (Family); a State, a government or a public authority (State); an industrial company (Industry). Widely Held refers to banks with no controlling shareholder.

Country	Bank	Investor	Family	State	Industry	Widely Held	Total
Austria	3	1	15	0	16	4	39
Belgium	15	0	0	0	21	0	36
Denmark	19	63	9	5	55	97	248
Finland	5	11	4	3	8	4	35
France	145	47	14	2	21	35	264
Germany	7	7	5	4	7	35	65
Greece	4	36	0	0	2	21	63
Ireland	0	4	0	12	1	2	19
Italy	25	22	15	5	24	78	169
Netherlands	13	0	2	0	0	3	18
Norway	48	16	3	0	90	228	385

Portugal	0	0	0	0	13	5	18
Spain	31	17	0	0	1	40	89
Sweden	0	6	0	0	39	11	56
Switzerland	2	0	0	125	6	17	150
United Kingdom	3	37	19	2	11	70	142
Total	320	267	86	158	315	650	1796

Table B.5

Correlations table

This table shows the correlations among the main explanatory variables used in the regressions. Concentration1 is the percentage of shares held by the largest controlling shareholder; Concentration is the sum of ownership percentages held by all controlling shareholders of each bank; LnTA is the natural logarithm of total assets; EQTA is the ratio of total equity to total assets; ROA is the ratio of net income to total assets; LOTA is the ratio of net loans to total assets; LLP is the amount of loan loss provisions divided by net loans; MTB is the ratio of the market value of equity to the book value of equity; ZScore is a measure of bank default risk computed as $ZScore = (ROA + EQTA)/SDROA$, where SDROA is the 3-year rolling standard deviation of ROA; AssetCommonality is a measure of the extent of banks assets similarity (details on the definition of Asset Commonality are provided in Appendix A); GDPGrowth is the real GDP (Gross Domestic Product) growth rate; MarketShare is the ratio of the market share of the three largest banks in each country; DIS is the deposit insurance schemes index; CAP is the capital stringency index; DIV is the asset diversification index. p-values are shown in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Concentration1 (1)	1														
BPI (2)	0.8551	1													
	(0.000)														
LnTA (3)	0.0378	0.0074	1												
	(0.109)	(0.753)													
EQTA (4)	0.0889	0.0885	-	1											
	(0.000)	(0.000)	(0.000)												
ROA (5)	-	-	-	0.3668	1										
	(0.535)	(0.929)	(0.000)	(0.000)											
LOTA (6)	0.0180	-	-	-	-	1									
	(0.446)	(0.020)	(0.000)	(0.000)	(0.113)										
LLP (7)	-	-	-	-	-	0.0713	1								
	(0.102)	(0.703)	(0.002)	(0.543)	(0.000)	(0.002)									
MTB (8)	0.2028	0.2161	0.0769	-	0.1567	-	-	1							
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.013)								
ZScore (9)	0.1825	0.1053	-	0.0171	0.0516	0.2086	-	0.0220	1						
	(0.000)	(0.000)	(0.030)	(0.474)	(0.030)	(0.000)	(0.000)	(0.355)							
AssetCommonality	-	-	0.5059	-	-	-	0.0956	0.0621	-	1					
	(0.011)	(0.013)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.008)	(0.006)						
GDPGrowth (11)	0.0367	0.0310	-	0.0408	0.2189	0.0184	-	0.1476	0.0651	-	1				
	(0.119)	(0.189)	(0.000)	(0.083)	(0.000)	(0.436)	(0.000)	(0.000)	(0.006)	(0.001)					
MarketShare (12)	-	-	0.2008	0.2024	0.0549	-	-	0.0858	-	-	0.1382	1			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.021)	(0.015)	(0.000)	(0.000)	(0.057)	(0.075)	(0.000)				
DIS (13)	-	-	-	0.1809	0.0029	-	0.1241	-	-	-	-	0.1196	1		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.903)	(0.166)	(0.000)	(0.000)	(0.000)	(0.509)	(0.000)	(0.000)			
CAP (14)	-	-	0.1209	-	-	-	0.1188	0.0326	-	0.1769	-	0.1411	0.1433	1	
	(0.928)	(0.479)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.167)	(0.218)	(0.000)	(0.000)	(0.000)	(0.000)		
DIV (15)	0.2185	0.0923	0.2589	0.0377	-	-	-	-	0.2434	-	-	0.0837	-	0.2149	1
	(0.000)	(0.000)	(0.000)	(0.109)	(0.171)	(0.003)	(0.000)	(0.002)	(0.000)	(0.001)	(0.381)	(0.000)	(0.000)	(0.000)	

Appendix C

This appendix presents the robustness estimation results.

Table C.1

Ownership concentration and banks' systemic risk during sound and distress times

This table reports the estimation results of the model presented in Eq.(1) over three period scenarios: (1) the financial crisis of 2008-2009 (Panel A); (2) the debt crisis of 2010-2012 (Panel B); and (3) the Covid19 pandemic crisis of 2020-2021 (Panel C). The dependent variable is the absolute value of ΔCoVaR defined as the mean of weekly ΔCoVaRs calculated as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median. Our variable of interest is the OwnershipConcentration defined as follow: (1) Concentration1 is the percentage of shares held by the largest controlling shareholder, (2) BPI is the Banzhaf Power Index that measures the relative controlling power of each shareholder among the bank's largest controlling shareholders (details on its definition and computation are provided in the Online Appendix A). The risk-taking incentives and assets commonality channels are respectively measured using the $d(\text{ZScore})$ and $d(\text{AssetCommonality})$ variables: $d(\text{ZScore})$ is a dummy variable taking a value of one if the variable ZScore is lower than the median value, and zero otherwise; $d(\text{AssetCommonality})$ is a dummy variable taking a value of one if the Asset Commonality variable is higher than the median value, and zero otherwise (details on the definition of Asset Commonality are provided in the Online Appendix A). Bank level variables is a vector of control variables including: Lagged dependent variable, LnTA, LnTA2, EQTA, ROA, LOTA, LLP, MTB, $d(\text{ZScore})$ and $d(\text{AssetCommonality})$. Country level variables is a vector of control variables at the country level including: GDPGrowth, MarketShare, DIS, CAP and DIV. Hansen test is a test of exogeneity of all instruments as a group. AR2 test is a test of the absence of second order residual autocorrelation. P-Values (reported in parentheses) are based on robust standard errors. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

d(Channel)	d(ZScore)				d(AssetCommonality)			
	Normal times		Crisis times		Normal times		Crisis times	
Ownership measure	Concent	BPI	Concent	BPI	Concent	BPI	Concent	BPI
Panel A: Financial crisis								
OwnershipConcentra	0.0034** (0.0173)	0.23 (0.0)	0.0014* (0.0810)	0.13 (0.03)	0.0040** (0.0319)	0.29 (0.0)	0.0018** (0.0487)	0.12 (0.0)
d(Channel)*Ownersh	0.0021** (0.0334)	0.12 (0.0)	0.0015* (0.0806)	0.09 (0.07)	0.0007* (0.0704)	0.10 (0.0)	0.0005* (0.0803)	0.07 (0.0)
Bank level variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country level	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of	1080	108	181	181	1080	108	181	181
Number of banks	92	92	20	20	92	92	20	20
Hansen test (P-value)	0.1822	0.19	0.1765	0.16	0.1901	0.19	0.1985	0.19
AR2 test (P-value)	0.1620	0.16	0.1461	0.14	0.1662	0.16	0.1500	0.14
Wald tests: $\alpha_1 + \beta_1$	0.0055** (0.0317)	0.36 (0.0)	0.0029** (0.0400)	0.22 (0.00)	0.0047** (0.0355)	0.39 (0.0)	0.0023** (0.0462)	0.20 (0.0)

Table C.1

Panel B: Debt crisis								
OwnershipConcentra	0.0032** (0.0255)	0.24 (0.0)	0.0013* (0.0723)	0.14 (0.04)	0.0039* (0.0510)	0.30 (0.0)	0.0019* (0.0518)	0.11 (0.0)
d(Channel)*Ownersh	0.0020** (0.0444)	0.13 (0.0)	0.0016* (0.0725)	0.10 (0.06)	0.0009* (0.0825)	0.10 (0.0)	0.0007* (0.0644)	0.08 (0.0)
Bank level variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country level	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of	1080	280	1080	280	1080	280	1080	280
Number of banks	92	55	92	55	92	55	92	55

Hansen test (P-value)	0.1601	0.17	0.1605	0.17	0.1705	0.17	0.1711	0.16
AR2 test (P-value)	0.1725	0.16	0.1555	0.15	0.1732	0.16	0.1533	0.15
Wald tests: $\alpha_1 + \beta_1$	0.0052** (0.0415)	0.37 (0.0)	0.0029* (0.0510)	0.25 (0.01)	0.0048* (0.0568)	0.40 (0.0)	0.0026* (0.0511)	0.20 (0.0)
Panel C: Covid19								
OwnershipConcentra	0.0030* (0.0565)	0.25 (0.0)	0.0014* (0.0666)	0.14 (0.03)	0.0037* (0.0672)	0.29 (0.0)	0.0018* (0.0606)	0.10 (0.0)
d(Channel)*Ownersh	0.0019* (0.0511)	0.12 (0.0)	0.0015* (0.0612)	0.11 (0.07)	0.0010* (0.0796)	0.09 (0.0)	0.0006* (0.0531)	0.07 (0.0)
Bank level variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country level	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of	1080	255	1080	255	1080	255	1080	255
Number of banks	92	60	92	60	92	60	92	60
Hansen test (P-value)	0.1728	0.16	0.1516	0.14	0.1752	0.17	0.1566	0.14
AR2 test (P-value)	0.1633	0.16	0.1522	0.14	0.1760	0.18	0.1496	0.15
Wald tests: $\alpha_1 + \beta_1$	0.0049* (0.0626)	0.37 (0.0)	0.0029* (0.0622)	0.25 (0.02)	0.0047* (0.0511)	0.38 (0.0)	0.0024* (0.0705)	0.18 (0.0)

Table C.2

Ownership concentration and banks' systemic risk: calculating the annual ΔCoVaR as the median and rolling average of the weekly ΔCoVaRs

This table reports the estimation results of the model presented in Eq.(1) for the sample of 114 banks over the 2004-2021 period. The dependent variable is the absolute value of ΔCoVaR defined as the median (Panel A) or the 2-year rolling average (Panel B) of weekly ΔCoVaRs calculated as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median. Our variable of interest is the OwnershipConcentration defined as follow: (1) Concentration1 is the percentage of shares held by the largest controlling shareholder, (2) BPI is the Banzhaf Power Index that measures the relative controlling power of each shareholder among the bank's largest controlling shareholders (details on its definition and computation are provided in the Online Appendix A). The risk-taking incentives and assets commonality channels are respectively measured using the d(ZScore) and d(AssetCommonality) variables: d(ZScore) is a dummy variable taking a value of one if the variable ZScore is lower than the median value, and zero otherwise; d(AssetCommonality) is a dummy variable taking a value of one if the Asset Commonality variable is higher than the median value, and zero otherwise (details on the definition of Asset Commonality are provided in the Online Appendix A). The four models are performed on the sample of 114 banks of 1796 observations. Bank level variables is a vector of control variables including: Lagged dependent variable, LnTA, LnTA2, EQTA, ROA, LOTA, LLP, MTB, d(ZScore) and d(AssetCommonality). Country level variables is a vector of control variables at the country level including: GDPGrowth, MarketShare, DIS, CAP and DIV. The definition of all these variables is provided in Table3. Hansen test is a test of exogeneity of all instruments as a group. AR2 test is a test of the absence of second order residual autocorrelation. P-Values (reported in parentheses) are based on robust standard errors. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

	(1)	(2)	(3)	(4)
d(Channel)	d(ZScore)		d(AssetCommonality)	
Ownership measure	Concentration1	BPI	Concentration1	BPI

Panel A: the annual ΔCoVaR is the median value of weekly ΔCoVaRs

OwnershipConcentration (α_1)	0.0040*** (0.0000)	0.3111*** (0.0000)	0.0058*** (0.0000)	0.3413*** (0.0000)
d(Channel)*OwnershipConcentration (β_1)	0.0039*** (0.0005)	0.2022*** (0.0007)	0.0009* (0.0912)	0.1403* (0.0752)
Bank level variables	Yes	Yes	Yes	Yes
Country level variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.1990	0.2022	0.2000	0.2120

AR2 test (P-value)	0.1565	0.1923	0.1617	0.2021
Wald tests: $\alpha_1 + \beta_1$	0.0079*** (0.0000)	0.5133*** (0.0001)	0.0067*** (0.0000)	0.4816*** (0.0000)
Panel B: the annual ΔCoVaR is the 2-year rolling average of weekly ΔCoVaRs				
OwnershipConcentration (α_1)	0.0036*** (0.0026)	0.3041*** (0.0000)	0.0051** (0.0112)	0.3202** (0.0110)
d(Channel)*OwnershipConcentration (β_1)	0.0031** (0.0106)	0.1967** (0.020)	0.0006* (0.0994)	0.1252* (0.0811)
Bank level variables	Yes	Yes	Yes	Yes
Country level variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.1987	0.2101	0.2012	0.2125
AR2 test (P-value)	0.1601	0.1781	0.1635	0.1751
Wald tests: $\alpha_1 + \beta_1$	0.0067** (0.0120)	0.5008*** (0.0008)	0.0057** (0.0313)	0.4454*** (0.0010)

Table C.3

Ownership concentration and banks' systemic risk: the use of ΔCoVaR calculated at the 95% instead of 99%

This table reports the estimation results of the model presented in Eq.(1) for the sample of 114 banks over the 2004-2021 period. The dependent variable is the absolute value of ΔCoVaR defined as the mean of weekly ΔCoVaRs calculated as the difference between the VaR of the system when the institution is at the 5% percentile and the VaR of the system when the institution is at its median. Our variable of interest is the OwnershipConcentration defined as follow: (1) Concentration1 is the percentage of shares held by the largest controlling shareholder, (2) BPI is the Banzhaf Power Index that measures the relative controlling power of each shareholder among the bank's largest controlling shareholders (details on its definition and computation are provided in the Online Appendix A). The risk-taking incentives and assets commonality channels are respectively measured using the d(ZScore) and d(AssetCommonality) variables: d(ZScore) is a dummy variable taking a value of one if the variable ZScore is lower than the median value, and zero otherwise; d(AssetCommonality) is a dummy variable taking a value of one if the Asset Commonality variable is higher than the median value, and zero otherwise (details on the definition of Asset Commonality are provided in the Online Appendix A). The four models are performed on the sample of 114 banks of 1796 observations. Bank level variables is a vector of control variables including: Lagged dependent variable, LnTA, LnTA2, EQTA, ROA, LOTA, LLP, MTB, d(ZScore) and d(AssetCommonality). Country level variables is a vector of control variables at the country level including: GDPGrowth, MarketShare, DIS, CAP and DIV. Hansen test is a test of exogeneity of all instruments as a group. AR2 test is a test of the absence of second order residual autocorrelation. P-Values (reported in parentheses) are based on robust standard errors. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

d(Channel)	(1)	(2)	(3)	(4)
	d(ZScore)		d(AssetCommonality)	
Ownership measure	Concentration1	BPI	Concentration1	BPI
OwnershipConcentration (α_1)	0.0048*** (0.0000)	0.3033*** (0.0020)	0.0049*** (0.0000)	0.3100*** (0.0088)
d(Channel)*OwnershipConcentration (β_1)	0.0032*** (0.0012)	0.2092*** (0.0017)	0.0010* (0.0517)	0.1932* (0.0613)
Bank level variables	Yes	Yes	Yes	Yes
Country level variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.1990	0.2022	0.2000	0.2120
AR2 test (P-value)	0.1711	0.1821	0.1719	0.1888
Wald tests: $\alpha_1 + \beta_1$	0.0080*** (0.0000)	0.5125*** (0.0022)	0.0059*** (0.0000)	0.5032*** (0.0070)

Table C.4

Ownership concentration and banks' systemic risk: the use of alternative systemic risk measures

This table reports the estimation results of the model presented in Eq.(1) for the sample of 114 banks over the 2004-2021 period. The dependent variable is the absolute value of the Marginal Expected Shortfall MES (Panel A) and the absolute value of the systemic risk index SRISK (Panel B), both calculated at 99% level. Details on the definition of MES and SRISK are provided in the Online Appendix A. Our variable of interest is the OwnershipConcentration defined as follow: (1) Concentration1 is the percentage of shares held by the largest controlling shareholder, (2) BPI is the Banzhaf Power Index that measures the relative controlling power of each shareholder among the bank's largest controlling shareholders (details on its definition and computation are provided in the Online Appendix A). The risk-taking incentives and assets commonality channels are respectively measured using the d(ZScore) and d(AssetCommonality) variables: d(Zscore) is a dummy variable taking a value of one if the variable Zscore is lower than the median value, and zero otherwise; d(AssetCommonality) is a dummy variable taking a value of one if the Asset Commonality variable is higher than the median value, and zero otherwise (details on the definition of Asset Commonality are provided in the Online Appendix A). The four models are performed on the sample of 114 banks of 1796 observations. Bank level variables is a vector of control variables including: Lagged dependent variable, LnTA, LnTA2, EQTA, ROA, LOTA, LLP, MTB, d(ZScore) and d(AssetCommonality). Country level variables is a vector of control variables at the country level including: GDPGrowth, MarketShare, DIS, CAP and DIV. Hansen test is a test of exogeneity of all instruments as a group. AR2 test is a test of the absence of second order residual autocorrelation. P-Values (reported in parentheses) are based on robust standard errors. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

d(Channel) Ownership measure	(1)	(2)	(3)	(4)
	d(ZScore)		d(AssetCommonality)	
	Concentration1	BPI	Concentration1	BPI
Panel A: the dependent variable is MES				
OwnershipConcentration (α_1)	0.0032** (0.0112)	0.2611*** (0.0019)	0.0030*** (0.0067)	0.2452** (0.0172)
d(Channel)*OwnershipConcentration (β_1)	0.0017*** (0.0008)	0.1317** (0.0212)	0.0005** (0.0242)	0.1011* (0.0965)
Bank level variables	Yes	Yes	Yes	Yes
Country level variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.2123	0.2088	0.2056	0.2002
AR2 test (P-value)	0.1806	0.2102	0.1810	0.2109
Wald tests: $\alpha_1 + \beta_1$	0.0049*** (0.0081)	0.3928*** (0.0097)	0.0035*** (0.0076)	0.3463*** (0.0044)
Panel B: the dependent variable is SRISK				
OwnershipConcentration (α_1)	0.0034*** (0.0081)	0.2912*** (0.0020)	0.0036** (0.0132)	0.3001** (0.0215)
d(Channel)*OwnershipConcentration (β_1)	0.0025** (0.0312)	0.1722** (0.0101)	0.0007* (0.0618)	0.1400** (0.0304)
Bank level variables	Yes	Yes	Yes	Yes
Country level variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.1911	0.2017	0.2000	0.2035
AR2 test (P-value)	0.1712	0.1705	0.1732	0.1710
Wald tests: $\alpha_1 + \beta_1$	0.0059*** (0.0030)	0.4634*** (0.0095)	0.0043** (0.0110)	0.4401*** (0.0010)

Table C.5

Ownership concentration and bank systemic risk: the effect of ownership control threshold

This table reports the estimation results of the model presented in Eq.(1) for the sample of 114 banks over the 2004-2021 period. We set an ownership control threshold of 25% (Panel A) and 5% (Panel B) instead of 10%. The dependent variable is the absolute value of ΔCoVaR defined as the mean of weekly ΔCoVaRs calculated as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median. Our variable of interest is the OwnershipConcentration defined as follow: (1) Concentration1 is the percentage of shares held by the largest controlling shareholder, (2) BPI is the Banzhaf Power Index that measures the relative controlling power of each shareholder among the bank's largest controlling shareholders (details on its definition and computation are provided in the Online Appendix A). The risk-taking incentives and assets commonality channels are respectively measured using the $d(\text{ZScore})$ and $d(\text{AssetCommonality})$ variables: $d(\text{ZScore})$ is a dummy variable taking a value of one if the variable ZScore is lower than the median value, and zero otherwise; $d(\text{AssetCommonality})$ is a dummy variable taking a value of one if the Asset Commonality variable is higher than the median value, and zero otherwise (details on the definition of Asset Commonality are provided in the Online Appendix A). The four models are performed on the sample of 114 banks of 1796 observations. Bank level variables is a vector of control variables including: Lagged dependent variable, LnTA, LnTA2, EQTA, ROA, LOTA, LLP, MTB, $d(\text{ZScore})$ and $d(\text{AssetCommonality})$. Country level variables is a vector of control variables at the country level including: GDPGrowth, MarketShare, DIS, CAP and DIV. Hansen test is a test of exogeneity of all instruments as a group. AR2 test is a test of the absence of second order residual autocorrelation. P-Values (reported in parentheses) are based on robust standard errors. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

d(Channel) Ownership measure	(1)	(2)	(3)	(4)
	d(ZScore)		d(AssetCommonality)	
	Concentration1	BPI	Concentration1	BPI
Panel A: ownership control threshold = 25%				
OwnershipConcentration (α_1)	0.0042*** (0.0002)	0.3322*** (0.0009)	0.0056*** (0.0010)	0.3328*** (0.0018)
d(Channel)*OwnershipConcentration (β_1)	0.0037*** (0.0016)	0.2188*** (0.0017)	0.0011* (0.0737)	0.1571* (0.0633)
Bank level variables	Yes	Yes	Yes	Yes
Country level variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.2110	0.2108	0.2019	0.2031
AR2 test (P-value)	0.1777	0.2044	0.1708	0.2100
Wald tests: $\alpha_1 + \beta_1$	0.0079*** (0.0002)	0.5510*** (0.0015)	0.0067*** (0.0009)	0.4899*** (0.0021)
Panel B: ownership control threshold = 5%				
OwnershipConcentration (α_1)	0.0038*** (0.0052)	0.3173*** (0.0001)	0.0049** (0.0322)	0.3151** (0.0318)
d(Channel)*OwnershipConcentration (β_1)	0.0029** (0.0237)	0.1816** (0.0331)	0.0008* (0.0989)	0.1333* (0.0903)
Bank level variables	Yes	Yes	Yes	Yes
Country level variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.1960	0.2189	0.2074	0.2099
AR2 test (P-value)	0.1656	0.1799	0.1706	0.1700
Wald tests: $\alpha_1 + \beta_1$	0.0067** (0.0136)	0.4989*** (0.0010)	0.0057*** (0.0021)	0.4484*** (0.0017)

Table C.6

Ownership concentration of the global ultimate owner and bank systemic risk

This table reports the estimation results of the model presented in Eq.(4) for the sample of 114 banks over the 2004-2021 period. The dependent variable is the absolute value of ΔCoVaR defined as the mean of weekly ΔCoVaRs calculated as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median. OwnershipConcentration is defined as follow: (1) Concentration1 is the percentage of shares held by the global ultimate owner (GUO) if the bank has a GUO; and zero if it is widely held. The risk-taking incentives and assets commonality channels are respectively measured using the $d(\text{ZScore})$ and $d(\text{AssetCommonality})$ variables: $d(\text{ZScore})$ is a dummy variable taking a value of one if the variable ZScore is lower than the median value, and zero otherwise; $d(\text{AssetCommonality})$ is a dummy variable taking a value of one if the Asset Commonality variable is higher than the median value, and zero otherwise (details on the definition of Asset Commonality are provided in the Online Appendix A). The four models are performed on the sample of 114 banks of 1796 observations. Bank level variables is a vector of control variables including: Lagged dependent variable, LnTA, LnTA2, EQTA, ROA, LOTA, LLP, MTB, $d(\text{ZScore})$ and $d(\text{AssetCommonality})$. Country level variables is a vector of control variables at the country level including: GDPGrowth, MarketShare, DIS, CAP and DIV. Hansen test is a test of exogeneity of all instruments as a group. AR2 test is a test of the absence of second order residual autocorrelation. P-Values (reported in parentheses) are based on robust standard errors. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

Ownership measure $d(\text{Channel})$	(1)	(2)
	Concentration1= Concentration GUO	
	$d(\text{ZScore})$	$d(\text{AssetCommonality})$
OwnershipConcentration (α_1)	0.0021* (0.0813)	0.0023* (0.0765)
$d(\text{Channel}) * \text{OwnershipConcentration}$ (β_1)	0.0019** (0.0402)	0.0020** (0.0226)
Bank level variables	Yes	Yes
Country level variables	Yes	Yes
Year dummies	Yes	Yes
Number of observations	1796	1796
Number of banks	114	114
Hansen test (P-value)	0.2821	0.2556
AR2 test (P-value)	0.2231	0.2300
Wald tests: $\alpha_1 + \beta_1$	0.0040** (0.0207)	0.0043** (0.0199)

Table C.7

Ownership concentration and banks' systemic risk: Country factors effect

This table reports the estimation results of the model presented in Eq.(1) by substituting the regulatory variables with country dummies for the sample of 114 banks over the 2004-2021 period. The dependent variable is the absolute value of ΔCoVaR defined as the mean of weekly ΔCoVaRs calculated as the difference between the VaR of the system when the institution is at the 1% percentile and the VaR of the system when the institution is at its median. Our variable of interest is the OwnershipConcentration defined as follow: (1) Concentration1 is the percentage of shares held by the largest controlling shareholder, (2) BPI is the Banzhaf Power Index that measures the relative controlling power of each shareholder among the bank's largest controlling shareholders (details on its definition and computation are provided in the Online Appendix A). The risk-taking incentives and assets commonality channels are respectively measured using the $d(\text{ZScore})$ and $d(\text{AssetCommonality})$ variables: $d(\text{ZScore})$ is a dummy variable taking a value of one if the variable ZScore is lower than the median value, and zero otherwise; $d(\text{AssetCommonality})$ is a dummy variable taking a value of one if the Asset Commonality variable is higher than the median value, and zero otherwise (details on the definition of Asset Commonality are provided in the Online Appendix A). The four models are performed on the sample of 114 banks of 1796 observations. Bank level variables is a vector of control variables including: Lagged dependent variable, LnTA, LnTA2, EQTA, ROA, LOTA, LLP, MTB, $d(\text{ZScore})$ and $d(\text{AssetCommonality})$. Country level variables is a vector of control variables at the country level including: GDPGrowth and MarketShare. The definition of all these variables is provided in Table3. Hansen test is a test of exogeneity of all instruments as a group. AR2 test is a test of the

absence of second order residual autocorrelation. P-Values (reported in parentheses) are based on robust standard errors. ***, ** and * indicate significance respectively at 1%, 5% and 10%.

d(Channel) Ownership measure	(1)	(2)	(3)	(4)
	d(ZScore)		d(AssetCommonality)	
	Concentration1	BPI	Concentration1	BPI
OwnershipConcentration (α_1)	0.0042*** (0.0002)	0.3232*** (0.0071)	0.0055*** (0.0008)	0.3527*** (0.0000)
d(Channel)*OwnershipConcentration (β_1)	0.0034*** (0.0015)	0.2138*** (0.0002)	0.0010* (0.0779)	0.1565* (0.0826)
Bank level variables	Yes	Yes	Yes	Yes
Country level variables	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Number of observations	1796	1796	1796	1796
Number of banks	114	114	114	114
Hansen test (P-value)	0.2181	0.2211	0.1970	0.2021
AR2 test (P-value)	0.1672	0.1834	0.1708	0.1902
Wald tests: $\alpha_1 + \beta_1$	0.0076*** (0.0005)	0.5370*** (0.0006)	0.0065*** (0.0001)	0.5092*** (0.0000)

Declaration of Competing Interest

This is to certify that there is no conflict of interests related to the submitted paper titled “Systemic risk in European banks: does ownership structure matter?”, co-authored with Zainab Srour, Jean-Laurent Viviani and Mohamad Jezzini.

Highlights

- Effect of ownership concentration and ownership type on systemic contribution
- The risk-taking incentives and banks’ assets commonality channels are explored
- The sample includes 114 European listed banks over the 2004-2021 period
- Higher ownership concentration is associated with greater systemic contribution
- The effect is stronger for banks controlled by institutional investors or States