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Shareholding Network in the Euro Area Banking Market

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Abstract

Analyzing the topological properties of the network of shareholding relationships among the Euro Area banks we evaluate the relevance of a bank in the financial system respect to ownership and control of other banks. We find that the degree distribution of the European banking network displays power laws in both the binary and the weighted case. We also find that the exponents are linked by a scaling relation revealing a direct connection between an increase of control diversification and an increase of market power.

Results also reveal Single Supervisory Mechanism, recently introduced by the European Central Bank and based on banks' total assets is a good proxy for the systemic risk associated to a particular financial institution.

Moreover we study how control and wealth are structured and concentrated within the banking system. Interestingly, our analysis reveals that control is highly concentrated at banking level, namely, lying in the hands of very few important shareholders that have weak relationships between them. This means that each main holder controls approximately a separate subset of banks.

Keywords: Shareholding network, European banking system, Weighted graph, Power law.
JEL Codes: D85, E58, L14.
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1 Introduction

In the summer of 2007 many US and European leading banks were hit by a collapse in the value of mortgage-backed securities, which they had themselves been responsible for packaging. To the surprise of many, the poisonous securities turned out to constitute a major portion of their ultimate asset base.

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The sovereign debt crisis, which erupted in the Eurozone in 2010, has sent a second wave of ripples through the global banking system and prompted interventions by governments and central banks on a scale comparable to the programs implemented during the financial crisis of 2008-09.

As Mario Draghi, President of the ECB, pointed out: "*In an economy like that of the Euro Area, where about three-quarters of corporate finance comes from the banking sector, the impact on the real economy, investment and employment are serious.* (Mario Draghi, President of the ECB, November 2012)".

The crisis has revealed the networked nature of banking systems. As the events unfolded, it became clear that the consequences of such an interconnected system are difficult to predict. There exists a variety of connections among banks. The dependencies between financial institutions stem from both the asset and the liability side of their balance sheet. For instance, banks are directly connected through mutual exposures acquired on the interbank market. Likewise, holding similar portfolios or sharing the same quantity of depositors creates indirect linkages between banks. The intricate structure of linkages in the banking system can be naturally captured by using a network representation of this market.

The research in the field of network theory evolved so that different levels of analysis are nowadays possible and several approaches to measure financial linkages have been proposed. Several authors have approached financial systems through the study of linkages among banks, exploring the international banking system from time series of interbank liabilities and claims. The topological properties of some national interbank markets have been studied in [53], which analyzes the network topology of the interbank payments transferred between commercial banks by the Fedwire Funds Services. Another example is [34] exploring the credit relationships that exist between commercial banks and large companies in Japan. Empirical studies have also been carried out on some European national interbank markets [28], [16] throughout the analysis of the topological properties of the networks of Italian and Austrian banks.

Another line of research deals with interconnections among financial institutions through direct interaction networks (or control networks) which are useful to detect chains of control (e.g. stock ownership networks or board of directors networks) [37], [26]. The topics addressed can be grouped into three major categories: firstly, analyzing the dispersion or concentration of control [32], [52]; secondly, empirically investigating how the patterns of control vary across countries and what determines them [51]; and thirdly, studying the impact of frequently observed complex ownership patterns [14], [24], [33] such as the so-called pyramids [3] and cross-shareholdings (also known as business groups) [39]. Remarkably, the investigation of the financial architecture of corporations in national or global economies taken as a whole is just at the beginning [9], [21], [23], [44] and [56].

The complexity of the interbank system has been analyzed mainly through the study of financial flows but, to the best of our knowledge, the literature has not deeply focused on the study of the shareholding relationships between banks.

In this paper we analyze the topological properties of the network of shareholding relationships among the Euro Area banks. The aim of this work is to analyze systematically the complex structure of the banks' network in the Euro Area by a complex network approach, with a special attention to edge weights reflecting how ownership is distributed among banks.

Namely we employ the technique presented in [9] and in [37] but we deviate from this approach in two aspects: firstly, we focus only on the banking sector of the Euro Area and secondly we enlarge the analysis using also non listed banks. We adopt this overtures to understand to which extent the diversification of shareholdings in banks' portfolios gives a good estimate of the relevance of a bank in the market with respect to ownership and control of other banks. This, in turn, allows to determine the way in which banks can acquire control and to understand their weight in the banking market. Moreover, we estimate whether the Single Supervisory Mechanism (SSM), recently introduced by the European Central Bank (ECB) and based on banks' total assets could be a good proxy for the systemic risk associated to a particular financial institution. Finally we also focus on the economic implications for concentration and stability within our network.

We collect data from Bankscope Ownership Database, analyzing the behavior of 1534 banks. The 2298 links establish an ownership relationship between the entities, namely a bank and the corresponding controlled.

We find that the degree distribution of the European banking network displays power laws in both the binary and the weighted case. Thus the network display robust-yet-fragile behavior, meaning that, while in good times the network is seemingly robust, in bad times nodes can go into distress simultaneously. Thus, in the hypothesis that the structure of the ownership network is a good proxy for the skeleton of the banking network as a whole, its analysis is also important in the framework of the quantification of systemic risk.

We also uncover that the exponents are linked by a scaling relation, revealing a direct relationship between an increase of portfolio diversification and an increase of market power. Furthermore the SSM is able to consider the systemic risk associated to financial institutions thanks to a positive and direct relationship between the value of the total asset of each bank and its probability of connections to partners.

The procedure enables us to address important questions in economics, namely, how control and wealth are structured and concentrated across the banking market. Interestingly, our analysis reveals that control, and thus market power, is found to be highly concentrated at banking level, namely, lying in the hands of very few important shareholders. Indeed they have weak relationships between them, meaning that each main holder controls approximately a separate subset of banks.

The remaining of the paper is organized as follows: Section 2 briefly presents the network structure and the methodology we work with, Section 3 illustrates the existence of a power law distribution for the linkages in the network, showing the relationship between power law coefficients in the binary and in the weighted networks. Beside these results, the same model is employed to emphasize how the SSM deals with the systemic risk. Section 4 displays the results about the concentration in the European banking market. Section 5 discusses the economic implications of the main results and concludes.

2 Network Structure

2.1 Dataset

We collect the ownership data of the 1534 Euro Area banks from Bankscope database. The Bureau van Dijk (BvD) Ownership Database is a complete source for owners and subsidiary links worldwide, with over 30 million active and 245 million archived links, providing information on over 30 million companies. The shareholder information is gathered from several possible sources, including Annual Reports or privately written communications addressed by the company to BvD. The Ownership Database intends to track control relationships rather than patrimonial relationships. This is why, when there are 2 categories of shares split into Voting/Non voting shares, the percentages that are recorded are those attached to the category Voting shares.

Ownership relationships are divided into two sub-classes, direct or total, to consider the case in which a bank exert control in another financial institution by holding shares of a company, which is not necessarily a bank.

While this possibility biases the estimate of the number of investors of each bank (which can in principle be very large), it does not affect qualitatively the statistical properties of the controlled percentage of each reported bank.

2.2 The network

A graph $G = (V; E)$ consists of a set V of n vertices and a set E of m edges. A weight w_{ij}, $i, j = 1, ..., n$, is possibly associated to each edge $(i; j)$; in this case a weighted (or valued) graph is defined.

The degree k_i of a vertex i $(i = 1, ..., n)$ is the number of edges incident to it. A directed graph (digraph) is a graph in which all the edges are directed from one vertex to another. In a directed graph the in-degree k_i^{in} of a vertex i is the number of arcs directed from other vertices to i and the out-degree k_i^{out} of a vertex i is the number of arcs directed from i to other vertices.

Thus, the Euro Area banking network can be defined as a weighted-directed graph where nodes are banks joined by weighted-directed links that represent ownership relationships between financial institutions. That is, we have an outgoing link starting from the controlled bank and reaching its owner.

In our network construction, the out-degree k_i^{out} of a vertex can be considered as the number of owners of the corresponding bank, whereas the in-degree k_i^{in} shows the number of different banks controlled by bank i (for this reason it can be seen as the portfolio diversification for bank i).

The quantities k_i^{in} and k_i^{out} do not consider non-topological state variables assigned to the nodes themselves. A natural choice may be using the total assets value of banks in million US dollars ν_j, as a proxy for their size. As a consequence, a weight (Φ_{ij}) proportional to the economic value (total asset) that a bank has in other banks via its percentages of voting shares (w_{ij}) can be associated to each node:

$$k_i^{in,w} = \sum_j \Phi_{ij} = \sum_j w_{ij}\nu_j \quad (1)$$

In this way, $k_i^{in,w}$ represents a proxy for the market power of bank i. It can be the case that a bank has large total asset but no voting shares in other banks and thus its network control is zero. On the other hand, a small bank can acquire enormous network control via shares in institutions with large total asset.

The weighed out-degree $k_i^{out,w}$ of a vertex is the percentage of shareholders of the corresponding bank, but as discussed above, this is a biased quantity and we cannot deal with its statistical descriptions.

Figure 1 displays an example of the network structure in the case with only three banks. Suppose that bank A owns 5% of the shares issued by bank B and 50% by bank C. Suppose also that the total assets of B and C are 100$ and 200$, respectively; thus according to 1 we can state that bank A has $k_A^{in} = 2$ and $k_A^{in,w} = 105\$$.

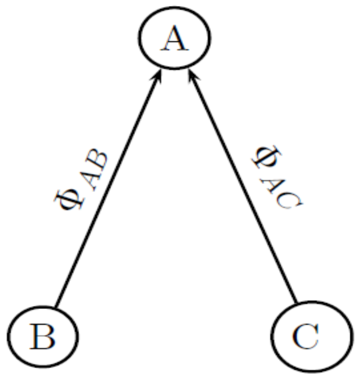


Figure 1: Example of the network structure with weighted links $\Phi_{AB} = w_{AB}v_B = 5$ and $\Phi_{AC} = w_{AC}v_C = 100$

Figure 2 shows the resulting network among Euro Area banks: it reveals the existence of some giant components and other weakly connected entities (here the size of the nodes are proportional to $k_i^{in,w}$). There are some bigger nodes with a higher value of the weighted in-degree (see Section 3) and a large portfolio diversification, reported from the values of the in-degree. Three French banks stand out with respect to this feature (Crédit Agricole S.A., BPCE S.A., BNP Paribas), but also banks from other countries, such as Deutsche Bank AG, ABN Amro Group N.V., KBC Groep NV and Intesa Sanpaolo.

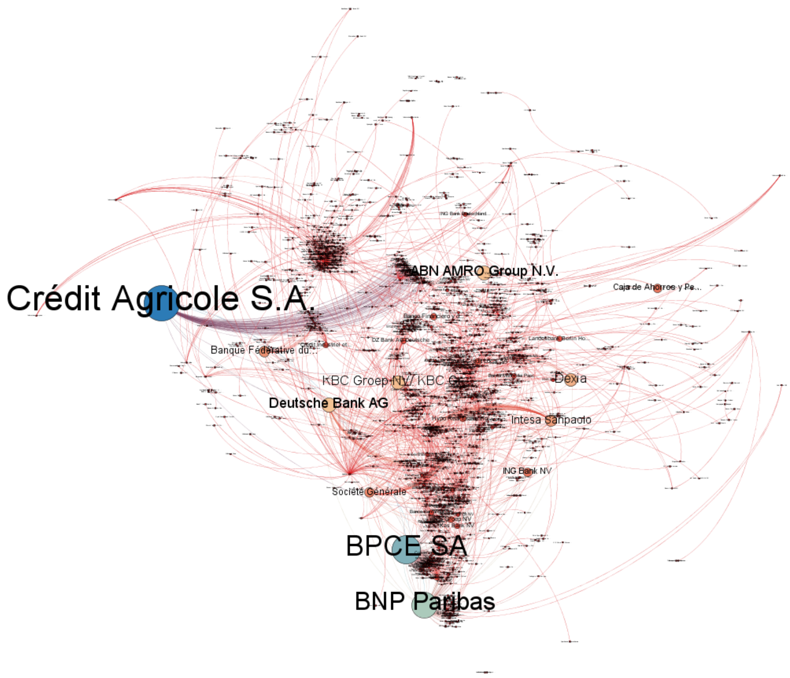


Figure 2: The control network for the Euro Area banks

In graph theory the clustering coefficient CC is a measure of the probability to which nodes in a graph tend to cluster together. In our case, this is the probability that two banks in the portfolio of a holder are institutions, one of which owns shares of the other. Evidence suggests that in most real-world networks, and in particular social networks, nodes tend to create tightly knit groups, characterized by a relatively high density of ties. Differently from social networks, shareholding networks have very small clustering coefficient [37]. In our case $CC = 0.002$. We can explain this feature considering banks making large and long term investments. In this case, institutions might prefer to avoid having stocks of interconnected banks in their portfolios because of the fear of contagion. Similar results are found in [19] regarding the shareholder networks in the NYSE, Nasdaq and MIB.

3 Power laws in the Euro Area ownership network

When the probability of measuring a particular value of some quantity varies inversely as a power of that value, the quantity is said to follow a power law, also known variously as Zipf's law or the Pareto distribution. Mathematically, a quantity x obeys to a power law if it is drawn from a probability distribution

$$p(x) \propto x^{-\alpha}$$

where α is a constant parameter known as the scaling parameter or exponent.

These topological features turn out to be extremely relevant because they have a strong impact in assessing networks' physical properties as their robustness or vulnerability [11], [22].

In order to characterize the topology of the banks control network, we estimate the probability distribution $P_>\left(k^{in}\right)$ of the number of vertices with in-degree greater than or equal to k^{in} and we test the hypothesis of power law curve, which means

$$P_>\left(k^{in}\right) \propto \left(k^{in}\right)^{1-\gamma} \tag{2}$$

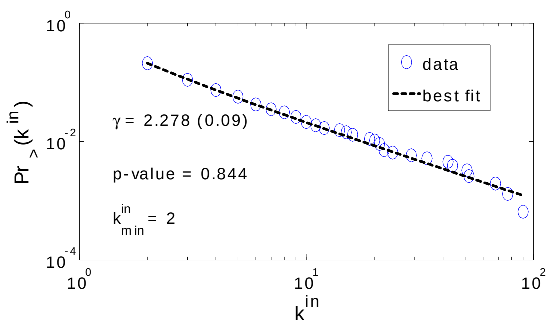
This corresponds (for large values of k^{in}) to a probability density $P\left(k^{in}\right) \propto \left(k^{in}\right)^{-\gamma}$ of finding a holder that controls exactly k^{in} banks.

We also perform the estimation of the probability distribution $P_>\left(k^{in,w}\right)$ of the weighted in-degree $k^{in,w}$, testing

$$P_>\left(k^{in,w}\right) \propto \left(k^{in,w}\right)^{1-\delta} \tag{3}$$

Namely we find the probability density function $P\left(k^{in,w}\right) \propto \left(k^{in,w}\right)^{-\delta}$ that a bank owns $k^{in,w}$ US millions of dollars of the other banks.

Since the detection and characterization of power laws is complicated by the large fluctuations that occur in the tail of the distribution—the part of the distribution representing large but rare events—and by the difficulty of identifying the range over which power-law behavior holds, our estimation strategy follows [20].



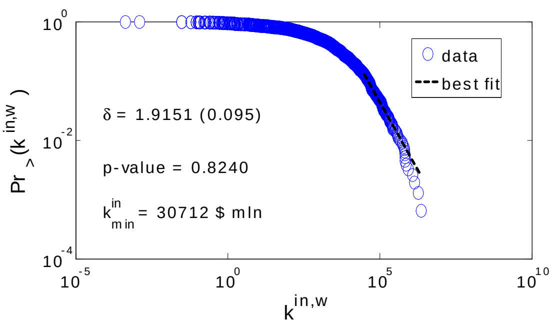


Figure 3: The cumulative distribution functions and their maximum likelihood power-law fits for: (a) k^{in} and (b) $k^{in,w}$

Figure 3 represents the cumulative distribution functions and the best fit for the in-degree k^{in} (a) and for the weighted in-degree $k^{in,w}$ (b). Results suggest that the values of the exponent differ across the type of networks. Indeed we find $\gamma = 2.278$ and $\delta = 1.9151$. It has also to be noticed that few empirical phenomena obey power laws for all values of a generic variable x. More often the power law applies only for values greater than some minimum x_{min}. In such cases we say that the tail of the distribution follows a power law. We find that $k^{in}_{min} = 2$ while $k^{in,w}_{min} = 30712$ US million dollars meaning that, in the binary case, banks that have more than 2 links follow a power law whereas, in the weighted case, this behavior is observed for banks that own, on average, more than 30712 US million dollars.

Consistently with [37], it has to be noted that the small $k^{in,w}$ range of $P_{>}\left(k^{in,w}\right)$ does not mimic the typical form displayed by power law distributions. Since in the following we are interested in $k^{in,w} > k^{in,w}_{min}$, the characterization of the left part of the distributions is however irrelevant, and we shall only consider the Pareto tails and the corresponding exponents.

3.1 Market power vs. control diversification

In this section we investigate whether any relation between k^{in}_i and its weighted counterpart $k^{in,w}_i$ can be established, thus understanding what is the relationship between market power and portfolio diversification. We employ the model developed in [10] and [18] letting $k^{in,w}_i$ to be dependent on k^{in}_i. Authors in [18] propose a mechanism leading to scale-free networks neither related to dynamic properties nor to preferential attachment [6]. They employ a fitness measure x_i, drawing links among vertices, with a probability depending on the fitness of the two involved nodes. This is a static model where the number of vertices is fixed (see [18], [38]).

At every vertex i a fitness x_i, which is a real number measuring its importance or rank, is assigned. Fitness are random numbers taken from a given probability distribution $\rho(x)$. For every couple of vertices, ij, a link is drawn with a probability $f(x_i, x_j)$ depending on the *importance* of both vertices.The simplest choice for the fitness function is the factorizable form $f(x_i, x_j) = g(x_i)h(x_j)$. However, since our information regarding k^{out} is incomplete, we cannot test the model with respect to the function $h(x_j)$, and in the following we consider the quantities derived from $g(x_i)$. Assuming $g(x)$ to be a monotonous function of x, we can calculate, for large enough number of nodes N, the in-degree distribution as:

$$P\left(k^{in}\right) = \rho\left[g^{-1}\left(\frac{k^{in}}{N}\right)\right]\frac{d}{dk^{in}}g^{-1}\left(\frac{k^{in}}{N}\right) \tag{4}$$

given that the connection probability is $g(x) = cx^{\alpha}$ ($\alpha > 0$, $c = 1$) and $x = \frac{k^{in,w}}{\max(k^{in,w})}$. Since we know that the statistical distributions of x is $\rho(x) \propto x^{-\delta}$ for x large, expression (4) now reads as

$$P\left(k^{in}\right) \propto \left(k^{in}\right)^{(1-\delta-\alpha)/\alpha} \tag{5}$$

Therefore using (2) and (5), we are able to find the following relation between the exponents:

$$\alpha = \frac{1-\delta}{1-\gamma} \tag{6}$$

obtaining the coefficient α corresponding to $k^{in,w}\left(k^{in}\right) \propto \left(k^{in}\right)^{1/\alpha}$.

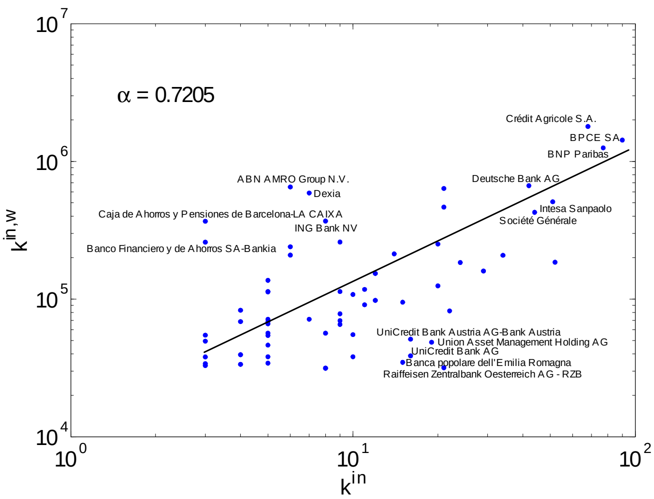


Figure 4: k^{in} vs $k^{in,w}$. The straight line is the curve $k^{in,w}\left(k^{in}\right) \propto \left(k^{in}\right)^{1/\alpha}$ with α predicted by eq. 6

Figure 4 shows the behavior of $k^{in,w}$ and k^{in}, where the straight line is the curve $k^{in,w}\left(k^{in}\right) \propto \left(k^{in}\right)^{1/\alpha}$ with α predicted by eq. 6. As the picture suggests, $k^{in,w}$ is an increasing function of the corresponding k^{in}, following approximately a straight line in double-logarithmic scale. Points that obey to this law (near or on the curve $k^{in,w}\left(k^{in}\right) \propto \left(k^{in}\right)^{1/\alpha}$) denote a direct relationship between an increase of portfolio diversification and an increase of market power. These points represent banks with many partners and wide ownership of other banks' asset. In particular, the most important hubs Crédit Agricole S.A., BPCE S.A., BNP Paribas, Deutsche Bank AG, and Intesa Sanpaolo are found to have many links and high market power.

Points below the straight line, correspond to banks holding high portfolio diversification but small market control power, informing that these banks have many small connections with many other banks. Therefore they are not the effective controllers of the corresponding banks. This is the case of two Austrian banks (RZB and UniCredit Bank Austria AG), two German banks (Union Asset Management Holding AG and UniCredit Bank AG), and one Italian bank, namely Banca popolare dell'Emilia Romagna.

On the contrary, points above the straight line correspond to banks whose portfolio has a large volume even if their diversification is small, e.g., Caja de Ahorros y Pensiones de Barcelona-LA CAIXA, Banco Financiero y de Ahorros SA-Bankia. This group encompasses also banks like ABN Amro Group N.V., ING bank NV and Dexia that are among the biggest nodes with a high value of the weighted in-degree. These banks have few but big connected partners.

As stated in [37], previous results support the hypothesis that the presence of non-topological quantities associated to the vertices (e.g. total asset) may be at the basis of the emergence of complex scale-free topologies in a large number of real networks.

3.2 The single supervisory mechanism

The European Central Bank (ECB) is recently acting on the Single Supervisory Mechanism (SSM) assuming ultimate responsibility for specific supervisory tasks, related to the financial stability of the biggest and most important Eurozone based banks.

The SSM will create a new system of financial supervision, comprising the ECB and the national competent authorities of participating EU countries. These countries include those whose currency is the Euro and those who have decided to enter into close cooperation with the SSM.

The main aims of the SSM will be to *"restore confidence in the supervision of all banks in the Euro Area"*, breaking *"the vicious link between sovereigns and their banks"* as President of the European Commission, Barroso, stated. The SSM shall ensure the safety of the European banking system increasing the financial integration and stability in Europe.

The ECB will be responsible for the effectiveness of the SSM, cooperating with the national governments of participating EU countries. The ECB will directly supervise significant credit institutions based on the total value of their assets, the importance for the economy of the country in which they are located or the EU as a whole, the significance of their cross-border activities and whether they have requested or received public financial assistance from the European Stability Mechanism (ESM) or the European Financial Stability Facility (EFSF).

In this framework the ECB will directly oversee almost 130 credit institutions, representing around 85% of total banking assets in the Euro Area. Considering the total asset as the main feature to select the significant credit institutions, this quantity could be only a raw proxy for the systemic risk associated to a particular bank. Indeed having a large value of total asset is more likely to be associated with many connections to other banks but it can not be always the case. To shed some insight about this possibility we repeat the previous exercise associating the total assets with the probability of possible connections a bank has. In particular, once we have proved that total asset follow a power law with exponent $\beta = 1.7285$, as the inset of Figure 5 shows, we can employ the model described by Eqs. (4)-(6) to find the relationship between the value of the total asset and the probability of the number of partners connected to a bank. We discover that the two quantities are linked by a scaling coefficient $\alpha_{ta} = 0.57$ denoting a direct relationship between the size of total assets and the number of connections. Moreover there exists an high correlation between the value of the total asset and the weighted in-degree, representing market power. Indeed notice that the same group that owns high portfolio diversification and market power (Figure 4), also has a large value of total assets. We point out that the 130 institutions under SSM are characterized by different connectivity behavior. Therefore only the banks located in the top right corner of Figure 5 display an high degree of systemic risk, while the remaining, having lower connections, are less prone to spread contagion.

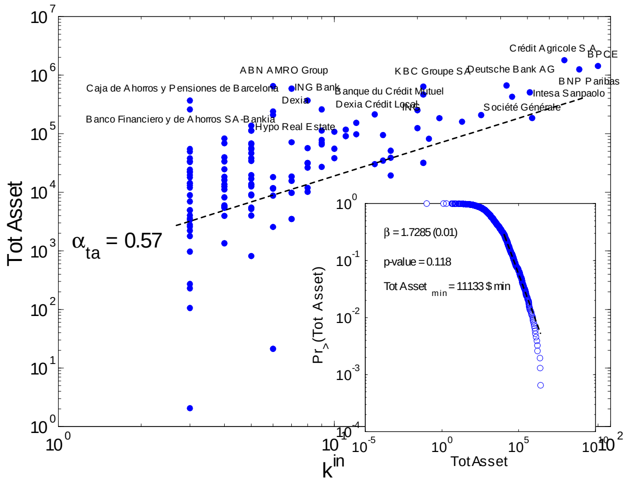


Figure 5: k^{in} vs Total Asset for the 130 banks under SSM.

4 Concentration in the Euro Area Banking market

The deregulation of financial services in the European Union, the establishment of the Economic and Monetary Union (EMU), the development of information technology and the last financial crisis are expected to contribute to changes in the European banking market. One of the consequences is evident in the process of concentration and, in particular, on local markets for banks' retail services [1]. From 1998 to 2002, the number of banks in the old EU financial landscape has been reduced by about 17%, from 9,337 in 1998 to 7,751 in 2002. The decline in the number of financial entities in the old EU-15 countries reflects mainly mergers and acquisitions between credit institutions [31].

As authors in [54] show, the consolidation process led to an increase in the concentration of most EU countries' banking sectors. On average, the five largest institutions' share of total assets amounted to 52% in the EU-15 in 2002.

To better explore concentration in the banking market, we define the following index as in [10]:

$$S_j = \frac{\left(\sum_{i=1}^{k_i^{in}} w_{ij}\right)^2}{\sum_{i=1}^{k_i^{in}} w_{ij}^2}$$

This quantity measures the number of prominent incoming edges incident to a node. Given our definition of the links, S_j is interpreted as the effective number of banks controlled by banks j. Note that this quantity is similar to the inverse of the Herfindahl index [41]. In the 1980s the Herfindahl index was also introduced to measure ownership concentration [25]. This index assigns high control to a bank with a small value in absolute terms, if this value is significantly bigger than the values of all the other shareholders.

In order to visualize concentration in the banking market, we show the cumulative control diagram (analogue to Lorenz curve with reversed axis) to unveil the distribution of the control within the market.Here, on the x-axis we rank the shareholders in descending order, according to their importance measured by S_j, whereas on the y-axis we display the corresponding percentage of controlled market value, defined as the fraction of the total market value they cumulatively control.

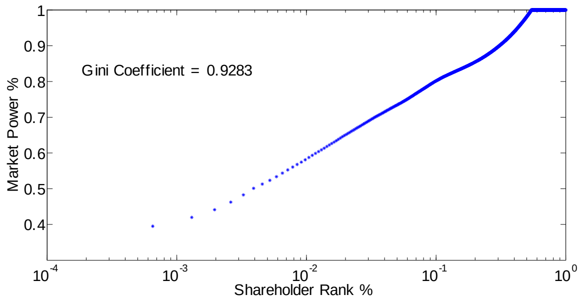


Figure 6: Lorenz curve in semilogarithmic scale

Figure 6 shows the cumulatively controlling percentage of the total market value. The top right corner of the diagram represents 100% of the shareholders controlling 100% of the market value, and the first data point in the lower left-hand corner denotes the most important shareholder of the Euro area, namely Natixis, owned by Groupe BPCE at 70%.

The figure emphasizes that the largest five banks in the Euro area own collectively, approximately 50% of the whole market. Furthermore a coordinate pair with value $(10^{-2}, 0.58)$ reveals that the top 1% of shareholders cumulatively control 58% of the banks in the market, while the coordinate $(10^{-1}, 0.8)$ suggests that the highest 10% of shareholders cumulatively control 80% of the total banks in the Euro area.

We also computed the Gini coefficient G which measures the statistical dispersion of market power distribution among banks.For the Euro area banking system we find $G = 0.9283$ meaning that the market structure of EU-15 banking sectors is generally characterized by high concentration.

A further step in the analysis shows how the main holders share out the market among themselves. We investigate the occurrence of different events: namely whether each main holder controls a separate subset of banks, or if the banks they control are largely overlapping or, again, if the main holders are divided in subgroups such that owners in the same group have overlapping banks ownership, but different groups have non-overlapping control over banks.

The first step is to consider a subnetwork restricted to the main holders and to the banks owned by this group. Here we consider the main holders as the top 1% of shareholders (see Figure 6).

Then we introduce a quantity that measures the number of important outgoing edges of the vertices [10]. For a given pair ij of node and destination vertex, one first defines a measure which reflects the importance of i with respect to all vertices connecting to j:

$$H_{ij} = \frac{w_{ij}^2}{\sum_{l=1}^{k_j^{in}} w_{lj}^2}$$

H_{ij} represents the fraction of control owner j has on bank i. Then, one defines the index:

$$h_i := \sum_{j=1}^{k_i^{out}} H_{ij}$$

This quantity is a way of measuring how important the outgoing edges of a node i are with respect to its neighbors' neighbors. In our context it measures the effective number of owners of the banks i.

Now, for each bank we keep only as many controllers as the rounded value of h_i. From the network restricted to the main holders, we obtain a subnetwork with the same number of nodes but with fewer edges as we have removed the weakest ones. The resulting network has 35 nodes and 38 edges and it is shown in Figure 7.

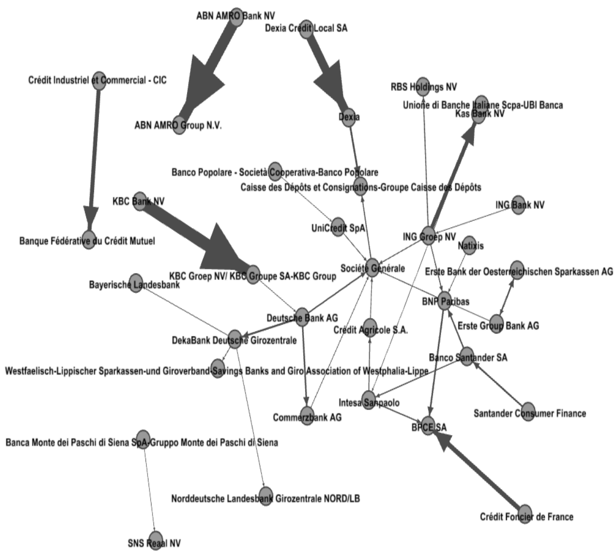


Figure 7: restricted network

Figure 7 shows that almost the main holders belong to the same big group, whereas some components consist of two nodes, namely, Dexia owns its French subsidiary Dexia Credit local or ABN AMRO and ABN AMRO Group N.V.. It has also to be noticed that the biggest links represent intra-group relationships.

The core group encompasses 29 banks from different countries, especially the most important French banks (i.e., Societe Generale, Credit Agricole, BPCE SA and BNP), or the Deutsche Bank, Dexia, Banco Santander, Intesa Sanpaolo from the rest of the Euro Area. The banks that display the highest out-degrees are ING Groep NV, Deutsche Bank, and BNP Paribas. Furthermore, even if tied together to form a core group, the major controllers in the Euro Area interbank market have weak relationships between them, meaning that each main holder controls approximately a separate subset of banks. Finally note that in this group, the core is surrounded by a geographically oriented periphery.

5 Discussion and Concluding Remarks

The power-law form of the statistical distributions of many quantities, including individual wealth [5], [30], [48], [50], firm size [55] and financial market fluctuations [36], [35], [47] seems to be a recurrent stylized fact. As in many other complex systems, the emergence of this behavior can be related to the interactions of a large number of agents [17], [43]. Indeed, the topology of various economic networks, ranging from those formed by directors of corporate boards [7] to those generated by the strongest asset correlations [15] is again characterized by power-law distributions.

Moving from these findings, we investigated what the implications for the European banking stability are. It is known that financial institutions establish financial contracts, such as lending or credit derivatives, with several other institutions. This allows them to diversify risk, but, at the same time, it also exposes them to financial contagion [1]. Unfortunately, information on these contracts is usually not disclosed due to strategic reasons. However, in various countries, the existence of such financial ties is correlated with the existence of ownership relations [42].

Thus, in the hypothesis that the structure of the ownership network is a good proxy for the skeleton of the financial network as a whole, its analysis is also important in the framework of the quantification of systemic risk [27]. Scale-free networks are typically robust with respect to the random breakdown of nodes and fragile with respect to intentional attack against the hubs. Indeed, while in good times the network is seemingly robust, in bad times firms go into distress simultaneously.

In the light of these considerations, the Single Supervisory Mechanism implemented by the ECB is related to the financial stability of the biggest and most important Eurozone based banks. The SSM shall ensure the safety of the European banking system increasing the financial integration and stability in Europe.

Implications for market competition have also to be considered. Previous works have shown how even small cross-shareholding structures, at a national level, can affect market competition in sectors such as airline, automobile and steel, as well as the financial one

[40]. Our results show that, in the European banking market, top banks are able to exert considerable control since they have strong ownership relations that could facilitate the formation of blocs, which would obstruct market competition [13].

In this paper we presented the topological properties of the network of shareholding relationships among the Euro Area banks. We adopted an interdisciplinary approach for the study of ownership and control. We analyzed the complex structure of the banks' relationships in the Euro area by a complex network approach, with a special attention to edge weights and how ownership is distributed among banks. We investigated how ownership structure gives information about the relevance of a bank in the market with respect to ownership and control of other banks. According to [10], in our ownership framework three levels of complexity play a role, namely, the topological features, the weights associated to each link and the possibility of assigning non-topological features (total asset) that shape the intrinsic structure of the network.

Our results revealed that the European banking network displays power laws in both the binary and the weighted case with exponent γ and δ respectively. The same model is applied to the institutions under SSM revealing a direct relationship between the size of total assets and the number of connections. Moreover there exists an high correlation between the value of the total asset and the weighted in-degree, representing market power. We point out that the 130 institutions under SSM are characterized by different connectivity behavior. Only banks with high value of total asset display a relevant degree of systemic risk, while the remaining, having lower connections, are less prone to spread contagion.

Moreover, the procedure enables us to address important questions in economics, namely, how control and wealth are structured and concentrated within the banking market. By means of appropriate concentration measures, the analysis enabled for extracting the essential structure of the core of the market. Interestingly, our investigation showed that control is found to be highly concentrated at banking level, namely, lying in the hands of very few important shareholders. This means that only a small elite of banks controls a large fraction of the market. This is also due to the fact that the banking system is highly heterogeneous and is arranged in a configuration with large banks borrowing from a large number of small creditors.

Finally, we found that the major controllers in the Euro Area interbank market, even if tied together to form a core group, have weak relationships between them. This means that each main holder controls a separate subset of banks.

An extension of this study to further years could help capturing the dynamic structure of the banking system and the possible changes in shareholding structure.

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