

# Central Banks in Organizational Networks

Entangled Market Actors

**Christoph F-D. Wu**

Citation:

Wu, C.F.-D. (2022). Central Banks in Organizational Networks: Entangled Market Actors (1st ed.). Abingdon, Oxon: Routledge.  
<https://doi.org/10.4324/9781003211945>

First published 2022  
by Routledge  
4 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

and by Routledge  
605 Third Avenue, New York, NY 10158

*Routledge is an imprint of the Taylor & Francis Group, an informa  
business*

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*British Library Cataloguing-in-Publication Data*

A catalogue record for this book is available from the British Library

*Library of Congress Cataloging-in-Publication Data*

Names: Wu, Christoph F-D., author.

Title: Central banks in organizational networks: entangled market actors /  
Christoph F-D. Wu.

Description: 1 Edition. | New York, NY: Routledge, 2022. | Series:  
Routledge international studies in money and banking | Includes  
bibliographical references and index.

Identifiers: LCCN 2022001624 (print) | LCCN 2022001625 (ebook) |  
ISBN 9781032078816 (hardback) | ISBN 9781032078830 (paperback) |  
ISBN 9781003211945 (ebook)

Subjects: LCSH: Banks and banking, Central. | Capital market. | Business  
networks. | Monetary policy.

Classification: LCC HG1811 .W779 2022 (print) | LCC HG1811 (ebook) |  
DDC 332.1/1—dc23/eng/20220302

LC record available at <https://lcn.loc.gov/2022001624>

LC ebook record available at <https://lcn.loc.gov/2022001625>

ISBN: 978-1-032-07881-6 (hbk)

ISBN: 978-1-032-07883-0 (pbk)

ISBN: 978-1-003-21194-5 (ebk)

DOI: 10.4324/9781003211945

Typeset in Times New Roman  
by Apex CoVantage, LLC

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## 4 Portfolio rebalancing and imitation

### Central bank influence and network dynamics

Financial networks are significant to society at large. Contagion spread through financial networks of cross-holdings during previous episodes of crises such as in Greece and peripheral Europe between 2010 and 2015. Portugal, Ireland, Greece and Spain contributed to severe financial duress in European capital markets in the years following 2010. In response, the European Central Bank (ECB) launched large-scale asset purchases, Europe's version of quantitative easing (QE), with their Public Sector Purchase Programme (PSPP) and Corporate Sector Purchase Programme (CSPP) to combat both market turmoil and disinflationary trends. With the increased globalisation of capital, financial networks are both growing in scale and complexity. Financial shocks spread through networks and impact society at large, creating the need for an approach to study financial networks, not based on asset price, trading volume or volatility correlations such as in financial economics,<sup>1</sup> but, as Schweitzer et al. (2009) call for, novel approaches that can combine the study of centrality with individual agent-based decision-making processes.

The objective of this chapter is to utilise the holdings-based network analysis introduced in Chapter 3 and apply this to one of the ECB's asset purchase programmes, the CSPP, and analyse how the ECB shapes financial networks as a central actor. More specifically, the chapter examines the microstructure of the European corporate bond market and analyses how the ECB shapes investment behaviour of the network. The CSPP is predominantly there to establish the ECB as a major investor in €-denominated non-bank corporate bonds by continuous purchases in both primary (buying directly from the issuing bank) and secondary (on the secondary market) bond issues. This process aims to inflate prices and reduce yields of said bonds and encourage other holders to sell and move to riskier bonds or those with a longer duration, in turn, improving financial conditions for the system and borrowing conditions for riskier and smaller companies. This migration to riskier assets is referred to as portfolio rebalancing effect.

This chapter offers an overview of the actual holders of the assets the ECB is purchasing and thereby examines the resultant beneficiaries and the observed network behaviour. European corporates have not faced such easy monetary conditions before and were encouraged to increase leverage. Likewise, bond investors benefitted from a free lift in prices of their portfolios.

QE had reached an unprecedented scale in late 2018 with the ECB's balance sheet alone amounting to almost €5tn.<sup>2</sup> This has caused discomfort not only with those European central bankers who pursue a more Germanic and hawkish philosophy but also with political bodies such as the Dutch parliament intensely questioning and criticising Mario Draghi, the then ECB president.<sup>3</sup> A hawkish stance reflects a focus on fighting inflation rather than economic growth. Since net purchases for the CSPP were halted in December 2018, it is necessary to analyse the dynamics of the CSPP network and potential distortions an unwind of positions could bring, should the policy reverse.

The chapter addresses the question of interlocking networks and profitability raised by Mizruchi (1996, p. 275) and tackled in recent research (Cohen et al., 2008, 2012). Using descriptive data, Section 4.3.4 discusses the decision methodology and the resultant mechanism of herding of central nodes in the network and indicates beneficial alignment with the central node. Analysing the ownership structure of financial markets in which the ECB is conducting monetary policy is important so as to see whether dominant actors in these markets are willing to leave their habitat for riskier assets as the portfolio rebalancing effect and central bankers suggest. Lastly, the overview of the holdings-based network of the European corporate bond market and the dynamics therein may contribute to the understanding of potential contagion and financial market risks a regulator has to take into consideration. With potentially concentrated and dense networks, financial shocks could be exacerbated with the need for central banks or other authorities to bail out individual market participants exposed to certain assets.<sup>4</sup> This is of significance to society as a whole as corporate bonds have been sold to retail investors, particularly in Spain and Italy through the local banks (European Commission, 2017, p. 40).

The chapter is structured as follows. Section 4.2 introduces the background and the two hypotheses analysed. Section 4.3 offers an overview of the background to the study, a description of the data collection and a brief literature review. Section 4.4 presents the results and analysis. The concluding discussion puts the findings into a broader context and elaborates on implications for the literature.

## **4.1 Hypotheses**

Whereas Baker (1984) saw the financial market as a physical property in the options exchange he was studying, he (1984, p. 806) also acknowledged that electronic trading could change some of the findings. Indeed over the past two decades, financial markets have become increasingly de-materialised (Knorr Cetina & Bruegger, 2002). Even Over-the-Counter (OTC) options, agreed between two parties rather than cleared by the exchange, are mostly traded through electronic communication tools – listed options are traded electronically on the exchange itself. Amid the proliferation of electronic trading and physical mobility, nodes in financial networks exchange and filter an increasing amount of information that is incorporated in investment decision-making. Within a network, nodes are increasingly aware of each other's positions, communications and constraints.

Early research into interlocking directorates contended that greater number of ties bring about increased intercorporate influence and economic interdependency, leading to common action (Mintz & Schwartz, 1981, p. 852). More recent research in corporate interlocks finds that higher intercorporate connections reduce diversity in decision-making and enhance social imitation in the network. Hence dense networks should result in stronger ‘Granovetterian’ ties and also similar investment decisions (Fracassi, 2016). Communications and actions from a central node in a given network can amplify certain actions and mechanisms also known as systemic feedbacks. Concentrated networks, for instance, can bear systemic risks, risks cascading from one node to the whole system, as seen in previous financial crises (Banerjee, 1992; Schweitzer et al., 2009, p. 424f). This can lead to herding and imitation in networks through information cascades (see e.g. Banerjee, 1992; Banerjee, Chandrasekhar, Duflo, & Jackson, 2013). Crises tended to emanate from unknown events, in which people are caught unaware. Hence imitation is not necessarily mindless, but it involves drawing rational inferences from limited information (Easley & Kleinberg, 2010, p. 484).

Monetary economics assumes that the portfolio rebalancing effect helps the transmission mechanism of the monetary policy. As a means to empirically examine this claim, economists look at asset price movements, in this case yield contraction, in asset markets ensuing announcements of monetary policy (Zaghini, 2019). Only a few studies capture changes in ownership (Nederlandsche Bank, Boermans, & Keshkov, 2018) and I am unaware of research, looking at the network of CSPP securities holders directly, specifically during the time prior to the announcement of the end of the programme. A network of eligible assets should as a result become less dense with central market participants, usually owning these assets, migrating to riskier securities with different maturities and credit rating.

In the context of this study, when the ECB becomes a significant investor in the market itself, does this lead to a dense network and imitation? Are investors following the ECB or migrating into riskier parts of the capital structure as the ECB president suggested? To assess such behavioural similarity is to measure the number of shared ties in the corporate interlocking network.

This leads to Hypothesis 1.

H1: The behaviour and positioning of the ECB leads to a comparatively dense network encouraging imitation and herding in eligible assets.

The hypothesis is tested by examining whether the strength of a connection in form of shared portfolio securities leads to an overlapping neighbourhood in the form of increased number of shared ties in the network.

Secondly, data gathering was conducted from March 2018 to March 2019, which spanned a time when the CSPP was both well-known to bond market participants and during which, the ECB also tapered (reduced monthly purchases), announced the future end of the programme (December 2018) and then halted net purchases for said programme (January 2019). The fact that the study was conducted almost 2 years into the purchasing programme has advantages in that

the network structure had time to form. However, it is difficult to make inferences on how the network was before the ECB started buying. To circumnavigate this limitation, the analysis included comparative measures through the Bloomberg Barclays European Corporate Bond index and the STOXX 600 Europe Equity index. Other central banks such as the BoJ actually conduct purchases of equities as part of their asset purchases so that it is an apt comparative measure. As a result, the Euro Stoxx 50 and the STOXX 600 equity indices were also analysed as part of testing Hypothesis 1.

Since the network analysis does not include the time before the ECB entered these securities in 2016, it is interesting to observe the change in the strength of ties during the exit phase, ‘on the way out’. If the network indicates strong tie characteristics as tested in H1, does the level of this bandwagon effect taper off with a fall in ECB purchasing activity?

This leads to Hypothesis 2.

H2: The level of strength of ties across the network decreases in line with the falling purchasing levels of the ECB.

## **4.2 The case study of the European Central Bank’s QE**

### ***4.2.1 ECB as market participant***

As the central bank for the eurozone, the ECB regulates money supply and interest rates and has a single mandate of price stability. Acting within this mandate, the ECB implemented unprecedented market-based monetary policy through its large-scale asset purchases, using the central bank’s balance sheet to accumulate eligible assets. Eligible assets are defined by the policy and are included in the Eurosystem Collateral Framework (ESCF) which currently consists of over 24,000 securities.<sup>5</sup>

The Fed had launched its QE in 2008. In a similar vein, the ECB launched its own version of QE, mainly with the PSPP. It was discussed in press conferences and other presentations in late 2014, announced in January 2015 and implemented in March 2015. The PSPP was part of the Extended Asset Purchase Programme (EAPP) as the ECB was already buying covered bonds and Asset-backed Securities (ABS). The CSPP was a further extension of the Asset Purchase Programme and was introduced in March 2016 and initially ended in December 2018. It aimed to include IG non-bank Corporate Bonds denominated in €.

After only a month of buying in July 2016, the ECB had already acquired around €7bn across 600 securities.<sup>6</sup> The number of issues included in the sample ranged from 1,100 to 1,200 for the study. Holdings were posted bi-weekly on the ECB website. After only two months of buying, the size of the CSPP amounted to €13.2bn,<sup>7</sup> eclipsing the then largest investment vehicle in the European corporate bond market, the iShares Eur Corp Bond ETF of €9.3bn.

These purchase programmes were born out of the need to raise inflation expectations for the eurozone during 2014 and were unprecedented. A central bank in Europe had never before purchased private debt securities on such a large scale, directly impacting idiosyncratic corporate risk and becoming a central node in the market itself. The justification for such a programme was based on the portfolio rebalancing effect. As Draghi put it, the purchases:

Not only alter the price of risk-free securities. . . . They also generate scarcity in the market in which we buy, which encourages investors to shift holdings into other asset classes – e.g. from sovereign to corporate bonds, from debt to equity, and across jurisdictions.

(Draghi, 2015b)

The example of the CSPP gives ample room to investigate how market participants interpret and incorporate new information from institutions into their decision-making processes. Through forward guidance, also known as the signalling process, the ECB reassures and gives a continuous detailed assessment of future purchases, duration and credit quality of the selected targets in a predefined list of bonds, available to the public. The market participants are mainly institutional investors managing investment vehicles such as mutual funds, hedge funds, pension funds or ETFs. PMs are tasked to invest funds according to the specific investment parameters laid out by their mandate.

Herding in the context of institutional investors has been studied in various context (see e.g. Chang, 2009; Hirshleifer & Hong Teoh, 2003; Kellard et al., 2017; Nofsinger & Sias, 1999; Sias, 2004; Spyrou, 2013). The bifurcation of investment choices into eligible and non-eligible corporate bonds at the announcement of the CSPP shaped the credit strategy significantly over the duration of the programme, as can be observed in many analyst notes either calling to buy CSPP eligible or non-eligible bonds (de Zeeuw, 2016; Jezek, 2016; Suttard, Kini, & Edwards, 2016). Once tapering of the CSPP unfolded in the reduction of monthly purchases, the question that market participants considered was the eventual end of the programme itself.

The question of how central banks influence financial markets with their monetary policy has been answered predominantly from an asset price, trading volume or volatility correlation perspective in investment research, monetary economics and central banking research. After the era of QE ensued, many sociologists and political economists have raised questions about the benefits of QE and large-scale asset purchases. This is important when evaluating the consequences of QE, be it moral hazard or overreliance and dependence on central banks.

#### ***4.2.2 Node considerations – active and passive***

Active versus Passive Investing is a wide-ranging debate in the literature (see Fama & French, 2010; Sharpe, 1991). In the context of the CSPP, Figure 4.1 lists the largest passive ETFs in the European corporate bond market. Index constituent



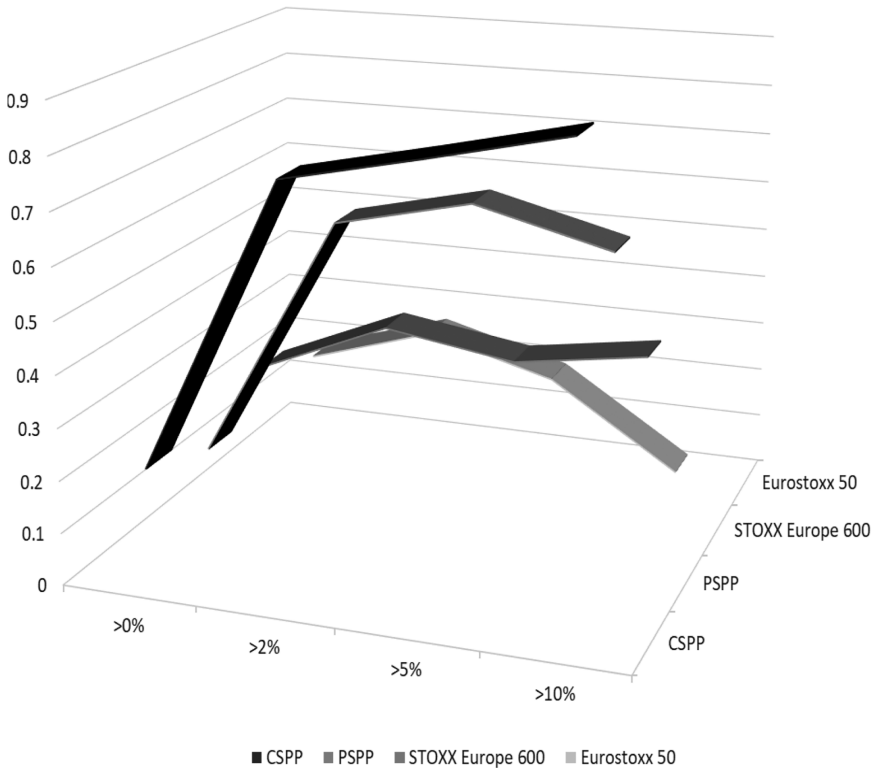


Figure 4.1 Network density at k1–k4 ownership levels

securities are bought in line with any new fund inflows and according to the index calculation elaborated in the following. Active funds, on the other hand, would consider which names to buy and when to dispose of positions based on proprietary analysis. If the ECB signals iterative buying in certain securities, active funds would face the dilemma of whether to a) buy the same securities and in a sense front-run buying behaviour of the ECB or b) move into riskier assets with lower credit rating or longer dated maturities. The former option would result in herding behaviour, the latter would be a portfolio rebalancing mechanism in that market participants move up the risk curve. In the bond market, one could either go into high yield or higher duration which bears higher risk in terms of interest rate and duration risk. In practitioners' terms, the rationale for portfolio rebalancing would be a spread contraction trade, that is the riskier bonds would benefit more than the IG bonds from improvements in financial conditions.

Only the active investor is in the position to consider this additional information, the forward guidance of the central bank and its intended course of action for market participants. In order for the active manager to make a return above the

benchmark, she could either consider buying the same securities quickly at lower prices with the ECB driving up prices thereafter through its anticipated purchases or assume that the contraction in spreads would be proportionately higher for lower quality and higher beta issues. Thus, from a network perspective, I would anticipate for the CSPP network to become denser over time as passive funds imitate the iterative buying behaviour of the ECB. The denser a network becomes over time, the more it indicates that herding takes place as formulated in Hypothesis 1.

Holders in a certain security of an index have a very specific reason for holding this. Given that, for instance, the ECB chooses the securities included in their purchasing programme with the help of the collateral framework and its eligible list of securities, this is by definition shaping the network. Consequently, the ECB's centrality in the network is not the main interest, but more so which market actors are very close in the network and what kind of reasons stand behind this.

### **4.2.3 Data collection**

Data gathering was conducted from March 2018 to March 2019. During this time span, the CSPP first became well-known to bond market participants and the ECB then tapered (reduce net purchases), announced the end of the programme and then halted net purchases altogether. The network analysis does not include the time before the ECB entered these securities.

The ISIN code for these securities is available on a bi-weekly basis from the ECB website and can easily be downloaded into Excel. Although the ECB publishes securities it had purchased online (CSPP holdings are made available for securities lending by the national banks), the amount purchased in each individual security is not given. There is a 70% issue limit. Given that the ECB is the largest single investor in the securities, the % ownership is equated with the given highest holder for the sixth, seventh and eighth node attribute (see further later). Thus, in each ego network, the ECB at least shares as many edges (connections) as the largest other node.

The nodes in the network are organisations holding the bonds in the CSPP and are mainly Investment Advisors (a broad category including mutual funds, ETFs, active Long Only Funds, passive funds), Banks, Pension Funds, Insurance Companies, Sovereign Wealth Funds, Governments, Individuals and Corporations. The edges represent the number of shared securities held between two nodes. By definition, the networks presented are both ego networks, dichotomous and edge-weighted networks of the ECB's CSPP programme recorded over a 1-year period.

Over the year, the maximum recorded  $N$  was 535, and there are on average 520–540 nodes in the network. Nine node attributes were recorded of which five were selected for the network analysis (Investor Type, Country, >2%, >5%, >10% ownership). The data were coded and reformatted using macros in Excel for use in the Gephi network visualisation tool (see Bastian, Heymann, & Jacomy, 2009) and UCINET Software (Borgatti, Everett, & Freeman, 2002).

The continuous % ownership data of securities of each individual node was split into a) the count of % ownership in Security  $S_n$  into a Pivot Table for each

Node  $N$ :  $S_{n1} \neq 0 = 1$  and  $S_{n2} = 0$  and b) the count of all non-zero % ownership in Security  $S_n$  into three further k-levels,  $> 2\%$ ,  $> 5\%$ ,  $> 10\%$ . The former was used to construct an edge-weighted Adjacency Matrix ( $M$ ) with the weight of the edges representing the Sum of the Count of Edges  $E_{ab}$  or  $E_{ab} = \sum_{i=1}^n S_{ab}^n$ . The latter was used as the sixth, seventh and eighth node attribute in the form of count of non-zero ownerships in levels k1, k2 and k3. The network boundaries were defined with a nominalist approach as described by Marsden (1990) and limited membership to the top 20 holders of the securities held by the ECB as part of the CSPP.

### 4.3 Results

#### 4.3.1 Network demographics and statistics

As of March 2019, the network of the top 20 holders of CSPP securities consists of  $n = 527$  holders. Out of the 527 holders, 77% are investment advisors (mutual funds, ETFs), 13% banks, 6% insurance companies and the balance is split between governments, hedge funds, pension funds, corporations, foundations, holding companies, brokerages and other. Around 17% of holders are domiciled in Luxembourg, 11% in Spain, 10% in France, 10% in the United States, 7% in the United Kingdom, 6% in Germany and 4.5% in Switzerland. The remaining funds are domiciled in Italy, Sweden, Austria, Canada and a few other small representations.

#### 4.3.2 Network structure

It is necessary in network analysis to work with comparisons. The STOXX Europe 600 index works well as comparison for the CSPP network structure, as it is the broadest equity index to measure the European stock market. It could also be a possible monetary policy target in the future and thus a potential policy measure.<sup>8</sup> The STOXX Europe 600 has a fixed number of 600 component stocks, incorporating stocks from 17 European Countries and is one of the broadest indices tracking European equities.<sup>9</sup> The number of constituent securities of the index comes a bit closer to those of the CSPP, rather than the often used Euro Stoxx 50. Hence, I take the STOXX 600 as a best way to reflect European Stocks and in turn the Bloomberg Barclays European Corp Bond index and the CSPP itself as reflection of European credit markets.

The CSPP is referred to as a two-mode network (Borgatti & Everett, 1997) with institutional holders and bonds. To analyse the network structure, the aforementioned data were first imported using UCINET software (Borgatti et al., 2002). Table 4.1 depicts the descriptive network statistics of the CSPP in relation to comparable networks. At a level of  $>0\%$  ownership, all financial networks show a similar density. However, the network density of the CSPP rises the most from 0.21 at  $>0\%$  to 0.76 at a  $>2\%$  threshold.

It is surprising to see how comparatively dispersed the European stock market ownership structure is on all the measured variables, Investor Type and Country

of domicile. It can also be concluded that the network of European corporate bonds in the CSPP is significantly smaller than that of equities and dominated by passive funds, in particularly ETFs. This is surprising as the CSPP consists of 1,201 securities as of 15 February 2019, whereas the broadest European equity index has only half the number of constituents. Likewise, a universe of thousands of single bond issues is essentially controlled by around 99 nodes at the 2% ownership level (see Table 4.1). In short, the ECB's targeted corporate bond market, as measured by the CSPP network, is notably denser than the European equity market in both the STOXX 600 and the Euro Stoxx 50.

By definition, the network diameter for the CSPP and PSPP is 2, as the ECB holds all the bonds in the networks. In a different market structure, the STOXX 600 has a relatively wide network diameter at 3. Figure 4.1 depicts how the network density outlined in Table 4.1 change. As the k-level threshold for membership is increased, the CSPP is becoming increasingly dense, rising continuously from 21% at k1 to 89% at k4. The ECB's sovereign bond purchase programme, on the other hand, rises initially as the threshold is increased but plateaus and then declines to 62% at k4, indicating that the largest holders are less connected compared to those at k4 in the CSPP. Likewise, and despite only consisting of 50 index constituent securities, the Euro Stoxx 50 equity index shows high disbursement at an ownership level of >10% with only one tie between ten nodes. With the broadest European equity index, the STOXX 600 index density is consistently between 25% and 35% across all k-levels indicating less holder concentration and density.

The following network visualisation illustrates the difference in density of the CSPP and the STOXX 600. The graphs were constructed using the Fruchterman–Reingold algorithm (Fruchterman & Reingold, 1991) and Gephi software (Bastian et al., 2009). Figure 4.2 shows the STOXX 600 top 20 holdings-based network visualisation for March 2019.

The size of nodes is based on Freeman's (1978) closeness centrality. The network shows a core of Investment Advisors and Banks but very mixed clusters

*Table 4.1* Comparable network statistics at >0% and >2%

Network Statistics	Indicators	STOXX			
		CSPP	PSPP	Europe 600	Eurostoxx 50
At >0%	Number of nodes	527	447	1,662	201
	Number of edges	29,318	18,134	648,476	3,674
	Average degree	111	75	390	37
	Density	0.21	0.16	0.24	0.18
	Network diameter	2	2	3	2
At >2%	Number of nodes	99	69	864	45
	Number of edges	3,752	1,486	259,694	264
	Average degree	76	43	301	12
	Density	0.77	0.63	0.35	0.26
	Network diameter	2	2	2	2

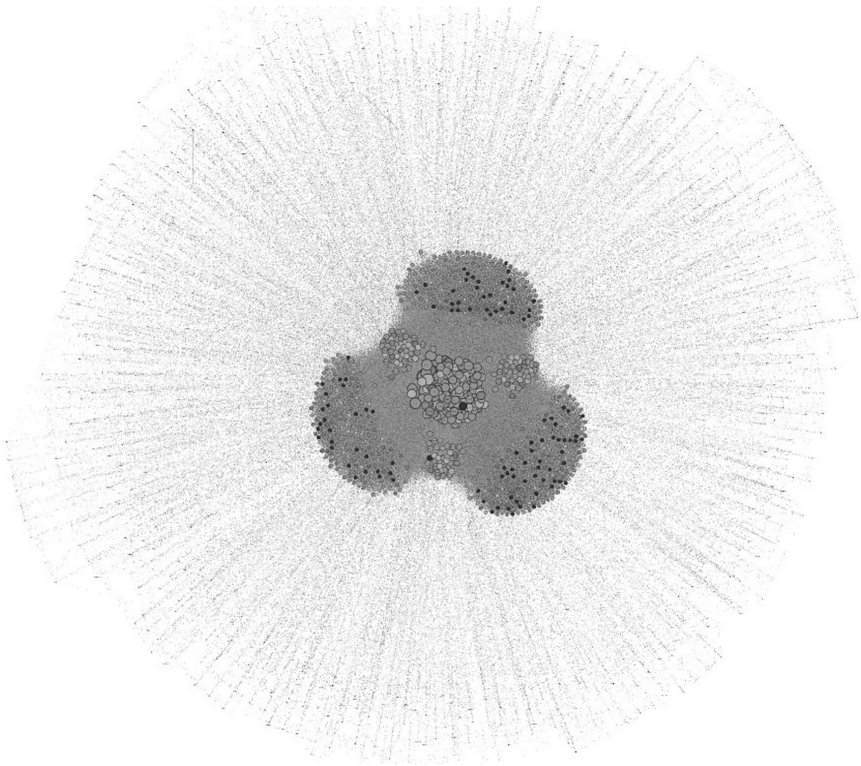
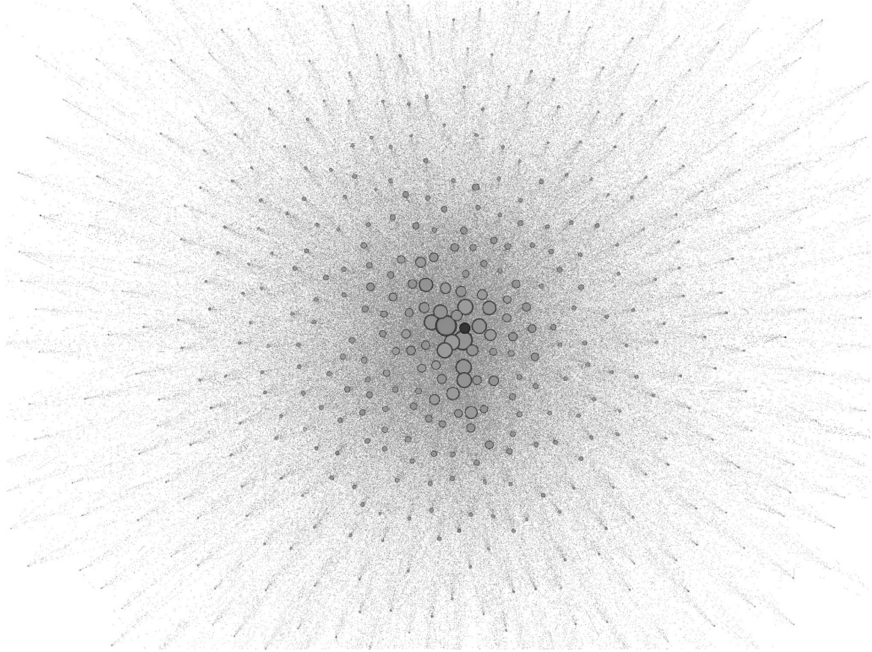


Figure 4.2 STOXX 600 top 20 holdings-based network

of nodes around the core. This stands in stark contrast to the CSPP ownership network in March 2019. In Figure 4.3, the ECB is the central node, classified under Investor Type ‘Government’. Immediate neighbours are predominantly Investment Advisors, Banks and Insurance Companies. Whereas European equities seem to have a very broad ownership network by Investor Type as seen in Figure 4.2, the CSPP network is dominated by asset managers and banks. That also implies that the benefits of the ECB’s QE are more concentrated among these interest groups, whereas equities would be much broader.

Given that the CSPP network is much more homogenous, this leads to a few inferences. At a >5% ownership level, the resultant concentration of nodes in the CSPP network is found in Figure 4.4 using the same technique as described earlier. The results show networks in April, July, October of 2018 and February 2019.

Over the observation period, the network graphs show the central positions of the US-based nodes Blackrock and Vanguard alongside the ECB. Both investment groups focus on predominantly passive investment strategies, and the largest investment vehicles in this network are ETFs. The graphs also show the central



*Figure 4.3* CSPP top 20 holdings-based network

German nodes Allianz, Deka, Union Investment and Deutsche Bank. While Deutsche Bank benefits from market making in bonds and syndication, the largest investment vehicles have become ETFs under the DB X-Trackers. Union Investment and Deka are the only central active asset managers in this network, while Pictet and Schrodgers are slightly away from the core. All other nodes in the core of the network graphs are following index rules or are essentially holding the bonds on their book for market-making purposes. This is a significant finding which will be explored in Section 4.3.4.

### **4.3.3 Centrality**

Linton Freeman (1978) developed the concept of closeness centrality. This is particularly useful for ego networks in which every node is connected through at least one node. In this network, every node is connected to the ECB by at least one connection. Closeness centrality takes into account not only the number of connections but also the number of shared connections with central nodes by incorporating the geodesic (shortest distance between given nodes  $i$  and  $j$ ). Closeness centrality takes the inverse of the geodesics of a node and in that way measures the efficiency and cost of exchanging information; short distance means

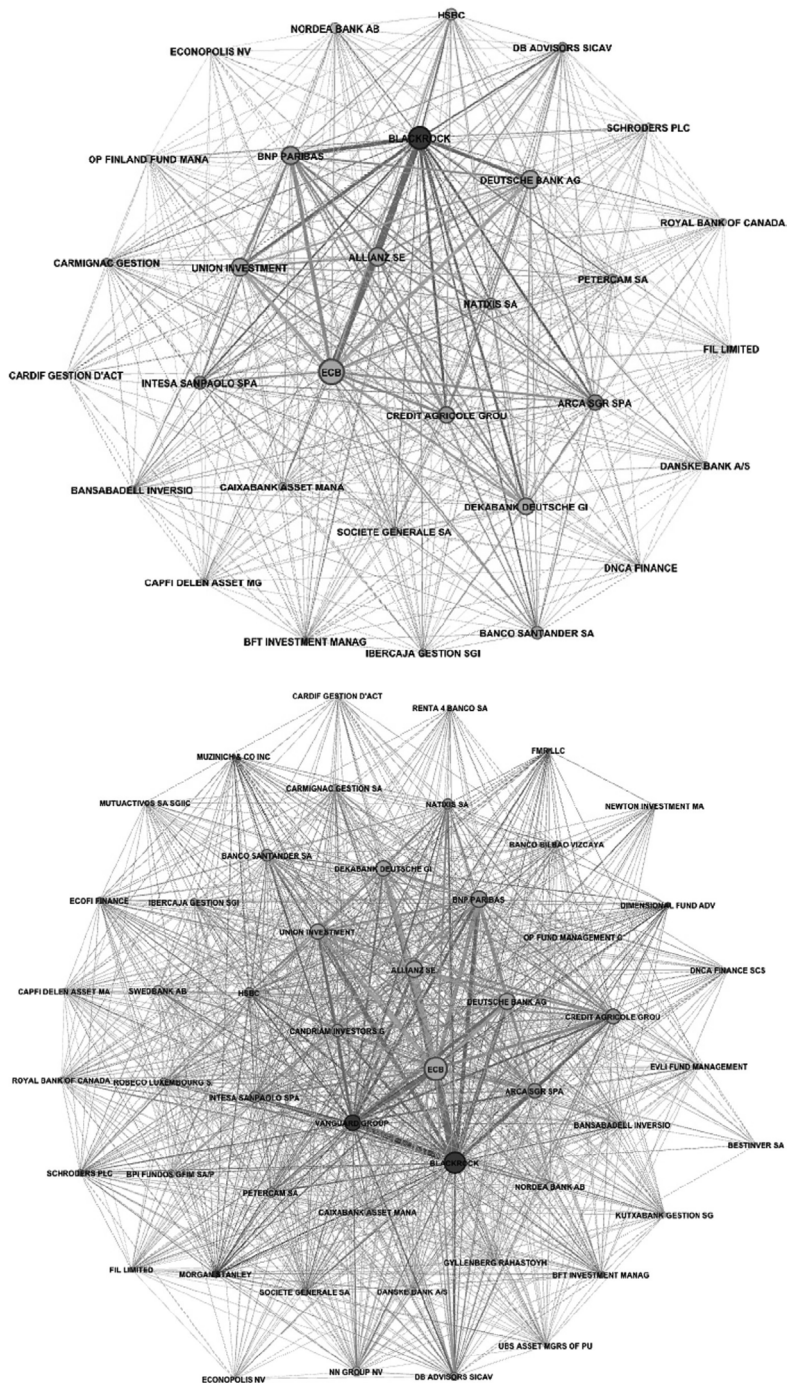


Figure 4.4 CSPP network with >5% partition and weighted edge size (April 2018–February 2019)

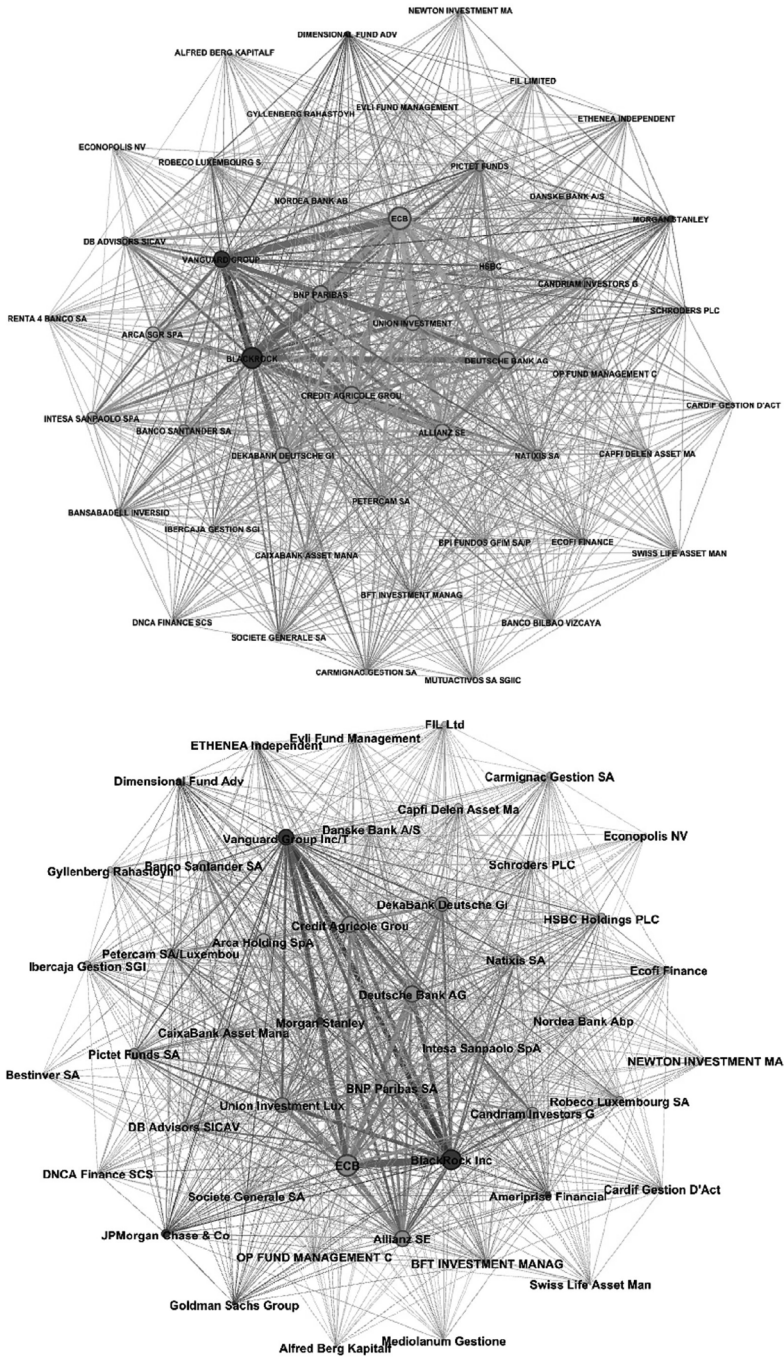


Figure 4.4 (Continued)



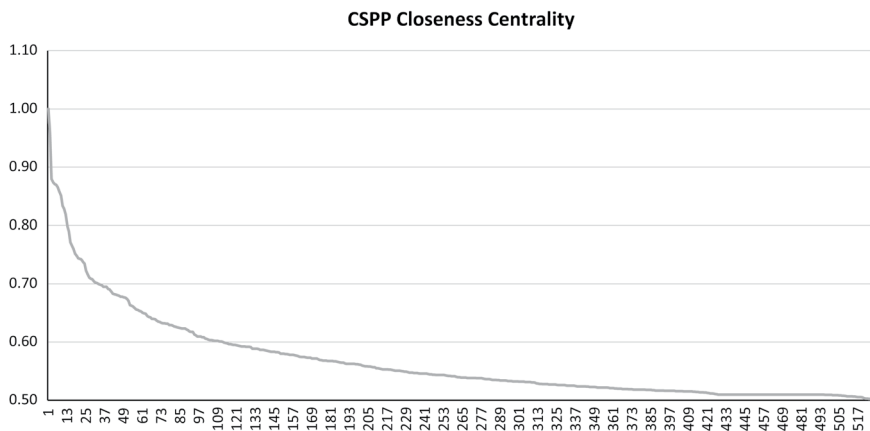


Figure 4.5 CSPP node chart listed by closeness centrality

faster and lower cost of transmissions (Brandes, Borgatti, & Freeman, 2016; Freeman, 1978). From this research point of view, I argue that this also raises the risk of contagion if central nodes on this matrix are following each other. The formula used for this is found in Freeman (1978, p. 225) as the equivalent of:  $C_c(i) = [\sum_j^N d(i, j)]^{-1}$ .

Using UCINET to calculate closeness centrality, Figure 4.5 shows a simple chart of the distribution of the values. The chart exhibits a very high concentration in the top 20 nodes after which the centrality scores drop quickly. Table 4.2 ranks the top 20 nodes by closeness centrality score. Out of the 20 nodes, there are only two very large active fund managers, German Deka and Union Investment. Nineteenth-ranked Hedge Fund Manager GAM also pursues an active mandate but is comparatively small in asset size. Indeed, eight out of the nine most central nodes are heavily focused on ETFs and these are the main holders of CSPP securities. Figure 4.6 corresponds well with the central nodes in Table 4.1. iShares belongs to Blackrock, X-Trackers to Deutsche Bank and SPDR to State Street.

#### 4.3.4 Herding and imitation

The descriptive statistics presented so far have shown how much denser the ego network of the ECB's CSPP is than comparable networks. Accounting for a >2%, >5% and >10% partition, this is even more exaggerated. The larger the holding size of securities, the larger the impact on prices of securities in the network of said nodes. The consequences of that are analysed subsequently.

The Bloomberg Barclays € Corp Bond index, a widely followed benchmark for European corporate bonds, rebalances monthly to reflect price changes during the

Table 4.2 Nodes table ranked by closeness centrality score

Number	ID	Closeness Centrality
1	ECB	1.00
2	BlackRock Inc	0.96
3	State Street Corp	0.88
4	Deutsche Bank AG	0.87
5	UBS AG	0.87
6	Credit Agricole Group	0.87
7	Allianz SE	0.87
8	Vanguard Group Inc/T	0.86
9	BNP Paribas SA	0.85
10	Union Investment Lux	0.83
11	Deka Bank Deutsche Gi	0.83
12	Arca Holding SpA	0.82
13	Credit Suisse Group	0.80
14	Zuercher Kantonalban	0.79
15	RAIFFEISEN BANK INTE	0.77
16	Candriam Investors G	0.77
17	Universal-Investment	0.76
18	Erste Group Bank AG	0.75
19	GAM Holding AG	0.75
20	Intesa Sanpaolo SpA	0.74

Name	AuM (\$m)	# of Holdings
iShares Core EUR Corp Bond UCI	9,293	2,475
Xtrackers II EUR Corporate Bon	875	1,995
SPDR Bloomberg Barclays Euro C	342	1,922
Invesco Euro Corporate Bond UC	45	313
Vanguard EUR Corporate Bond UC	0.06	721

Figure 4.6 Snapshot of largest ETFs tracking the Bloomberg Barclays Euro Corporate Bond index

Source: Bloomberg.

month which enables both active and passive investors to anticipate rebalancing with the following formula.<sup>10</sup>

$$\text{Market Value}_{\text{Bond}} = (\text{Price}_{\text{Bond}} + \text{Accrued Interest}_{\text{Bond}}) \\ * \text{Par Amount Outstanding}_{\text{Bond}}$$

As the ECB buys eligible securities, the  $\text{Price}_{\text{Bond}}$  rises and in turn increases  $\text{Market Value}_{\text{Bond}}$  and thereby spurs further purchases of nodes tracking the index. As the ECB was buying bond issues every month, this would affect the index value as for bond indices there is a far higher turnover of components, whereas, for example, for the STOXX Europe 600, there is usually an annual rebalancing

and only a few components change. As bonds approach maturity, they leave the index a year before maturity, thereby causing a higher need for bond portfolios to churn compared to equities.

Given that the network is comparatively denser and structured around the dominant passive ETF asset managers, the CSPP programme will inevitably distort the market structure more as would the same programme into equities. The closeness centrality scores are clustered around the top nodes, with 20 nodes recording over 0.8. The central nodes hold the securities predominantly in passive investment vehicles, thereby imitating the buying behaviour of the ECB on a large scale causing the herding of nodes 1 through 20.

Another way to test for connectedness in the network is to test for strength of ties by using both the dichotomous and the valued CSPP network data collected. Mark Granovetter's (1973) strength of weak ties idea suggests that nodes with a strong connection (in terms of the number of shared securities) are also increasingly connected to the same nodes, resulting, in this specific context, in herding. This follows the principle that strong ties resemble close-knit networks in which "a friend of my friend is also my friend" (Goyal, 2007, p. 127). In the CSPP network, having the same neighbourhood simply means that the group of nodes made the same investment decision to purchase ECB securities and indicates similarity in decision-making or imitation.

Borgatti and Feld (1994) first operationalised the strength of weak ties hypothesis in their UCINET software by utilising Hubert and Schultz's (1976) Quadratic Assignment Procedure (QAP) correlation. Their assumption is that the stronger the tie between two nodes, the more their neighbourhoods should overlap. In this procedure, the adjacency matrix of the valued network is correlated with the matrix depicting the number of people to which each node in a pair is connected to. In simple terms, the adjacency matrix of the valued network is dichotomised into a 0,1 adjacency matrix. This simple matrix  $A$  is then post-multiplied by its transpose  $A'$  using UCINET software (Borgatti, Everett, & Johnson, 2013). This is the overlap which counts the number of times each pair of rows has a 1 in the same column. A correlation between the valued network and the overlap with 5,000 permutations yields a Pearson's  $r$  value which can be tested for significance. This procedure compares the observed correlation with a distribution of random correlations. If the Pearson's  $r$  is significant compared to the p-value, the findings indicate strong support for a dense and strong tie network and is another way to look at the 'bandwagon' effect described in Hypothesis 1 earlier.

Table 4.3 shows the QAP dyadic correlation for the CSPP network, the network of the European corporate bond benchmark, as measured by the Bloomberg Barclays index and the broad European equity index. The results show that the nodes in the CSPP network share more nodes in common the stronger they are connected. While correlations for all asset classes are significant, the CSPP network scores the highest Pearson's  $r$  value compared to measures of the European corporate bond and equity market. The Pearson's  $r$  of 0.4834 for the CSPP network is a moderately strong and significant measure to indicate an imitation and bandwagon effect of well-connected nodes in the network. In other words, there

Table 4.3 Pearson Correlation CSPP, iShares Bloomberg Barc Euro Corp, STOXX 600 February 2019

Pearson Correlation (Nobs 5000)	1	2	3	4	5	6
	Obs Value	Sign	Average	Std Dev	Min	Max
CSPP	0.4834	0.0002	0	0.0167	-0.0432	0.0703
Bloomberg Barclays Euro (iShares)	0.4453	0.0002	0	0.0162	-0.042	0.0762
STOXX 600	0.148	0.0002	-0.0002	0.006	-0.0166	0.0219

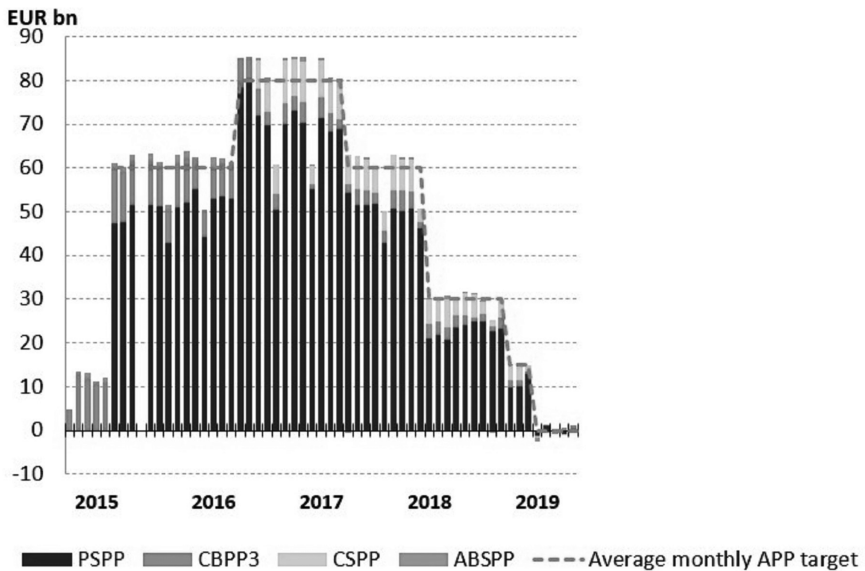


Figure 4.7 Diagram of ECB monthly net purchases by asset purchase programme

Source: ECB.

is a moderately strong relationship between the number of corporate connections nodes have in common and the extent of shared financial interest.

Since the data collection period does not include holdings data for 2016, before the implementation of the CSPP, I look at the effect of the ECB reducing asset purchases during the data collection phase from March 2018 to March 2019. This would imply that with falling purchases of the ECB, nodes should start to anticipate selling by the ECB and the bandwagon effect should taper off as described in Hypothesis 2. Figure 4.7 shows the extent of the reduction in the ECB's net purchases of CSPP-eligible bonds, particularly from March 2018 until January 2019, which falls into the data observation period.

To test this hypothesis, I ran the QAP correlation at different time points during the observation period. The signalling of an exit from QE by the ECB described

Table 4.4 Strength of ties test over the observation period

CSPP	1	2	3	4	5	6
Pearson Correlation (Nobs 5000)	Obs Value	Sign	Average	Std Dev	Min	Max
Apr-18	0.5015	0.0002	0.0004	0.0172	-0.0448	0.0861
Jul-18	0.4991	0.0002	-0.0002	0.0169	-0.0522	0.0681
Sep-18	0.4929	0.0002	-0.0001	0.0168	-0.0501	0.0784
Dec-18	0.4861	0.0002	-0.0003	0.017	-0.0491	0.0745
Mar-19	0.4779	0.0002	-0.0005	0.0166	-0.0544	0.0725

in Section 4.2, as well as the reduction of purchase behaviour in Figure 4.7 has led to a decrease in the measure of strong ties across the network in Column 1 of Table 4.4. While the Pearson's  $r$  remains significant indicating a strong-tie network, the correlation steadily decreased over the observation period in line with the reduction in purchasing behaviour of the ECB.

#### 4.3.5 Analysis

Both the descriptive statistics of the overall network structure of the ECB's ego network in CSPP securities and the related correlation analysis have shown that the network is comparatively dense and has tendencies to encourage imitation and herding of nodes around the bonds purchased by the ECB. Nodes unaware of the passive herding in the CSPP network will be impacted significantly as liquidity constraints continue to surface given the operationally difficult way to implement the monthly rebalances discussed in Section 4.3.4. This network mechanism may cause longer-term liquidity problems as central active managers are sparse and usually fulfil the role to arbitrage mispricing in the market and make it more efficient and thus liquid (see e.g. European Union, 2017, p. 22). The dense network structure coupled with this herding mechanism will enable contagion to spread easily throughout the whole network and will be amplified should a node among the top 20 face selling/redemption pressure. In addition, there are only a few active managers to balance this risk and buy at distressed levels to act as contrarians.

Previously, the European Commission Expert Group on European Corporate Bonds (2017) pointed out the prevalence of active managers in European corporate bond markets, but this is not reflected in the ECB's CSPP ego network. Indeed, the comparative analysis of the CSPP with sovereign purchases of the ECB in the PSPP and the generic equity indices in Europe show that given the structure of the European corporate bond market, the ECB has a disproportionate network effect.

## 4.4 Conclusions

This chapter contended that by publishing the eligible bonds, announcing the anticipated buying amounts in their policy and becoming the largest investor in that market, the corporate interlocking network of the ECB results in herding

behaviour based on an endorsement effect. This network mechanism enables market participants to both imitate and adjust portfolios, either in mechanical ways such as the index trackers described in Section 4.3.4 or active managers anticipating ECB behaviour in the network. As shown, this also applies to when the ECB is exiting the network incrementally, in the form of the reduction of purchase amounts. By comparing the European corporate bond market to equities, it also transpired that the network structure of the ECB's chosen policy tool enhances imitation based on the technical investment methodology of the most central nodes. This network structure inevitably leads to distortionary conditions as the ECB's behaviour is imitated by central nodes in the network causing cascades and a bandwagon effect. It will also make an exit for the ECB out of this network difficult without significant ripple effects. After January 2019, the ECB was replenishing maturing bonds maintaining a static balance sheet size. Once the policy would require reduction of the balance sheet, that is net selling of eligible bonds, it would be difficult for any node to take up that selling pressure given the network imitation of central nodes. It will likely amplify the negative effects of exiting QE.

The ECB has become a gigantic node in the European corporate bond networks but is not able to implement what the policy set out to do, namely, to push central nodes out of eligible securities into riskier ones as intended by the portfolio rebalancing effect. By imitating the behaviour of the ECB, central nodes benefit from bond price increases. Interlock centrality in this network results in economic benefits by central nodes profiting from price increases of bonds included in the ECB purchases. Hence, this chapter explored yet another way in which nodes can benefit from corporate interlocks, addressed in other network research (Cohen et al., 2008, 2012; Fracassi, 2016).

Competition in the market, defined here as divergent behaviour by economic agents, is reduced. The denser network structure then facilitates a domination of the ECB through the mirroring of positions by close central nodes. This cannot be seen as a healthy development and is an unintended consequence of QE. As discussed in Section 4.3.2, the role of active asset managers such as Deka and Union Investment becomes ever more important to balance and arbitrage price inefficiencies and distortions. The European Commission's Expert Group on European corporate bond markets recommended the European Commission and the European Securities Market Association (ESMA) to encourage corporate bond ETF trading given the arguably positive impact on price discovery and liquidity (European Commission, 2017, p. 51). In light of the findings in this chapter, ETFs that follow a formulaic investment methodology described in Section 4.3.4 will exacerbate contagion in the network, as ETF redemptions have to be met with actual sales of the underlying assets causing a negative feedback loop. Given the centrality of the ETF instruments in the CSPP holdings-based interlocking network, ETF redemptions and underlying bond sales could also cause concerns for retail investors holding single issues that are included in the ETFs.

## Notes

- 1 See e.g. Brida, Matesanz, and Seijas, (2016), Dimitrios and Vasileios (2015) and Roy and Sarkar (2011, 2013).
- 2 Retrieved April 3, 2020, from [https://www.ecb.europa.eu/pub/pdf/other/ecb.eurosyste\\_mbalancesheet2018~5b51d1aefe.en.pdf?eea517404936d72c65611c1bb3553ee6](https://www.ecb.europa.eu/pub/pdf/other/ecb.eurosyste_mbalancesheet2018~5b51d1aefe.en.pdf?eea517404936d72c65611c1bb3553ee6)
- 3 German sentiment towards QE had been resentful from the likes of Jens Weidmann, Otmar Issing, Jürgen Stark, and also of politicians across Germany and the Netherlands questioning the legality of sovereign bond purchases.
- 4 The prime example would be the bail out of AIG in mortgage-backed securities during the Lehman crisis in 2008/2009.
- 5 The collateral framework is updated regularly and detailed positions are available under. Retrieved April 3, 2020, from <https://www.ecb.europa.eu/paym/coll/html/index.en.html>
- 6 See Jezek (2016) for details.
- 7 Retrieved April 3, 2020, from <https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html#cspp>
- 8 The BOJ, for instance, chose to include equity ETFs in their QE.
- 9 See Retrieved April 3, 2020, from <https://www.stoxx.com/index-details?symbol=SXXP> for more details.
- 10 Here is an excerpt from the index methodology:

The Projected (Statistics) Universe is a dynamic set of bonds that changes daily to reflect the latest set of index-eligible securities. As an up-to-date projection of the next month's Returns Universe, the Projected Universe assists active managers by providing them with the necessary insight to modify their portfolios ahead of any index changes and assists passive managers by preparing them for any executions needed ahead of monthly rebalancing. Indicative changes to securities are reflected daily in both the Projected and Returns Universes of the index and may cause bonds to enter or fall out of the Projected Universe, but will affect the composition of the Returns Universe only at month-end. The examples below illustrate how several transactions are treated in the Returns and Projected Universes over the course of a month.

(Bloomberg Professional Service, 2017, p. 49)

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