The Chemical Brothers

Competition and the Evolution of the Board Interlock Network in the German Chemical Industry, 1950–2015

Buch-Hansen, Hubert; Grau Larsen, Anton

Document Version
Accepted author manuscript

Published in:
Business History

DOI:
10.1080/00076791.2021.1923696

Publication date:
2024

License
Unspecified

Citation for published version (APA):
Buch-Hansen, H., & Grau Larsen, A. (2024). The Chemical Brothers: Competition and the Evolution of the Board Interlock Network in the German Chemical Industry, 1950–2015. *Business History*, *66*(1), 157-180. https://doi.org/10.1080/00076791.2021.1923696

The chemical brothers:
Competition and the evolution of the board interlock network in the German chemical industry, 1950-2015

Hubert Buch-Hansen and Anton Grau Larsen

Hubert Buch-Hansen
Department of Organization
Copenhagen Business School
Kilevej 14a
2000 Frederiksberg
Denmark

Email: hbu.ioa@cbs.dk

Anton Grau Larsen
Department of Organization
Copenhagen Business School
Kilevej 14a
2000 Frederiksberg
Denmark

Email: agl.ioa@cbs.dk

Abstract

Utilising a unique and original dataset on the board composition of the 35 largest German chemical producers over the 1950-2015 period, the article tracks the entire lifespan of the industry's reconstituted board interlock network. Regarding the network as a mechanism for controlling competition among its members, we consider changes in its strength over time. We find that a close-knit network came into existence in the 1950s, culminating in the 1970s and 1980s, after which it began to weaken. We highlight the importance of various meeting places for top-level directors from the chemical industry, including bank boards, and moreover introduce a novel measure that makes it possible to consider the significance of past ties to the strength of the network. Situating the findings in a wider political-economic context, we suggest that in important respects Germany's coordinated form of capitalism is likely to have been even more coordinated than has been recognised.

Keywords: Germany, Corporate networks, Chemical industry, Competition, Banks

Introduction

Due to concerns about their negative effects on competition, board interlocks (also known as interlocking directorates) among large competitors were made illegal in the United States in 1914.[1] By contrast, no such legislation was introduced in Europe. In Germany, dense board interlocks and ownership tie networks, in which big banks occupied central positions, became an integral part of the country's cooperative type of capitalism (Fohlin, 2007; Hilferding, 1910; C. Marx & Reitmayer, 2019; Windolf, 2002; Ziegler et al., 1985). For instance, these networks connected companies operating in the same sectors, and prior to the Second World War, they existed alongside extensive cartelization in German industry. After the war, the Allies were to some extent successful in 'decartelizing' Germany and, in the 1950s, a competition law was adopted that prohibited cartels (albeit with the possibility of exemptions). According to Windolf (2002: 6-7), the subsequent structure of Germany's corporate networks (board interlock and ownership networks) 'can be viewed as a transformation of earlier cartel structures. Simplified*: The corporate networks replaced the cartels*'. Indeed, various scholars have noted that the post-war corporate networks existing among the largest German financial and non-financial companies – networks frequently referred to as *Deutschland AG* (Germany Inc.) – served to mute competition among their members (e.g., Streeck 2009: 77-78).

Most studies on *Deutschland AG* have focused on networks connecting the largest German companies and thus by implication on networks that were primarily *inter*-sectoral. Much less attention has been devoted to networks linking the boards of same-sector companies. Thus, little is known about intra-sectoral board interlock networks and how they have evolved over time. The present article contributes to remedying this deficiency in the existing scholarship. We take the evolution of the board interlock network in the German chemical industry as our case. Historically, Germany has been an international leader in this industry (Chandler, 1990, 2005), and to this date, it remains a global heavyweight. A German company (BASF) is the world's largest chemical producer (measured in terms of turnover) and in 2015 the German chemical industry accounted for no less than 28% of the total sales in the European

market (GTAI, 2018). Several studies have dealt with this industry and its companies (Aftalion, 2001; Jones & Lubinski, 2014; C. Marx, 2019; Schröter, 1997; Wengenroth, 2007), yet the evolution of its board interlock network has yet to be analysed.

Relating to the fields of business history, economic sociology and political economy, the present article contributes empirically and methodologically to the scholarship on the long-term evolution of corporate networks (David & Westerhuis, 2014; Lemercier, 2015; Lluch et al., 2019; Rubio-Mondéjar & Garrués-Irurzun, 2016), German capitalism and the chemical industry. Utilising a unique and original dataset on the board composition of the 35 largest German chemical producers over the period of 1950-2015, we cover the entire lifespan of the industry's reconstituted board interlock network. That is, while being under allied control in the immediate aftermath of the Second World War, there were no board interlocks in the industry. Starting from this 'blank slate', we track the formation of the network and how it evolved up to the present day. We do this with the goal of answering the following overarching research question: *How did the strength of the board interlock network in the German chemical industry change over time?* To gauge the strength of the network, which we take as an expression of its ability to serve as a mechanism for controlling competition among its members, we consider changes in both the number and nature of network ties over the 66-year period. Investigating how the network developed over this long period allows us to shed new light on the nature of corporate coordination in Germany and to analyse how some of the wider changes in German capitalism affected the development of the chemical industry's network. For instance, we relate the observed developments to research on the disintegration in the 1990s of *Deutschland AG*. Such research notes the significance of regulatory changes and altered ownership relations. Moreover, it highlights how big banks were transformed in ways prompting them to withdraw their directors from the supervisory boards of industrial companies (e.g., Beyer & Höpner, 2003; Streeck, 2009).

We find that a close-knit board interlock network came into existence in the German chemical industry in the 1950s, culminating in the 1970s and 1980s, after which it began to weaken somewhat. Aside from focusing on long-term year-on-year network evolution, we move beyond standard analyses of board interlock networks in at least two respects. First, we bring the connections between chemical companies created via various *third-party*

venues into focus, including the industry's main business association and the boards of the major German banks. Contrary to what the existing scholarship on corporate networks in Germany would lead us to expect (Windolf, 2014: 75-76; Ziegler et al., 1985: 10), we find that for several years bank boards served as important meeting places for top-level directors from the chemical industry. Second, we take into consideration *history* by mapping how previous board affiliations (if any) of directors create ties between boards in the absence of a current board interlock. Introducing this novel network measure, we find that in some periods the already high connectivity of the network increases substantially. Against the background of these findings, we suggest that in important respects Germany's coordinated form of capitalism is likely to have been even more coordinated than suggested by existing scholarship.

The first section outlines the perspective on board interlock networks and competition informing this article, and moreover presents and motivates the sub-questions through which we answer the overarching question. In the second section, we account for our data and methods. The three following sections answer the sub-questions, before the sixth section discusses our key findings in light of extant research on the German chemical industry and *Deutschland AG*. A concluding section summarises our main findings.

1. Corporate networks and competition

Fligstein (2001: 5) observes that '[f]irms try to find ways to control the worst aspects of competition in order to continue to exist. Much of the market-making project is to find ways to stabilize and routinize competition. Much of the history of the largest corporations can be read as attempts to stabilize markets for these firms in the face of ruinous competition and economic downturns'. He notes that one of the ways in which competitors can seek to manage the intensity of competition is by forming social relations (networks) with one another (2001: 5). Along the same lines, some of the scholarship in the literature on corporate networks suggests that intra-sectoral board interlocks may be used by companies to reduce competition, even contributing to facilitate cartels, i.e., (illegal) agreements between competitors to restrict competition. For instance, Windolf (2014: 79) notes that

‘[i]ntra-sectoral ties may be used as a coordination device to support the cartel organization in each industry’ (see also Eichenberger & Ginalski, 2016; Schnyder & Wilson, 2014). Intra-sectoral interlocks do not, however, need to play a role in relation to cartel agreements – a role that is questioned by Mizruchi (1996: 274) – to have the effect of muting competition. Intra-sectoral ties may also serve to facilitate ‘tacit collusion’, meaning that they help competitors abstain from competing with one another without an explicit agreement to this effect (see Jacobs, 2014). That is, such interlocks can serve to mute competition by creating *venues* in which corporate directors can discuss problems and develop common understandings and *channels* through which inside information, including information about corporate strategies, travel between boards (Buch-Hansen & Henriksen, 2019).

It is worth reiterating that *inter- and intra-sectoral board interlocks are qualitatively different*. Obtaining access to privileged information or a business scan is argued to be among the main reasons why *inter*-sectoral interlocks occur (Useem, 1984: 44). Given that two connected companies are not in competition, the flow of privileged and sensitive information between boards is relatively unproblematic. In contrast, an *intra*-sectoral tie exposes two competing companies to one another. A member of the board knows the strategy, product pipeline, etc., of both companies and has a direct influence on the formulation of said strategy. In effect, the two companies thus have a partially shared corporate governance. For this reason, most of the ties identified in the following analysis would be illegal under the US antitrust system: they would violate Section 8 of the Clayton Act, which prohibits board interlocks between competitors of a certain size. Certainly, intra-sectoral interlocks should not be assumed to have one function only: like other interlocks, they can simultaneously serve multiple purposes. For instance, they can be a mechanism for owners or creditors to monitor and/or exercise control over a firm, they can reinforce elite or class cohesion by constituting meeting places for corporate directors, and for individuals holding interlocking directorships they can be used to establish contacts and gain influence and prestige (for reviews of some of the literature, cf. Buch-Hansen & Henriksen, 2019; David & Westerhuis, 2014a: 3-5; Sapinski & Carroll, 2018). Nevertheless, if the boards of the companies in an industry are connected, they can be assumed to affect the intensity of competition. The stronger such a board interlock network is, the better it may enable companies to control (mute) competition. To assess the strength of the network – in this case, the board interlock

network in the German chemical industry – we focus on several issues. These issues are covered by various sub-questions to which we now turn.

SQ1: To what extent were the companies in the population connected?

With the first sub-question, we address various aspects related to how connected the companies in our population were. One aspect is the *cohesiveness* of the network (e.g., Prell, 2012). If companies in a sector are connected by few interlocks, we should see a network with several disconnected components. Such a network will not be a useful instrument for limiting competition. Conversely, if most of the companies are connected in a large component, it significantly increases the possibility that the network is being used to mute competition. A related aspect is the *proximity of companies* in networks. How many companies is each company in the population connected to on average via board interlocks (average degree), and how many other companies in the population do they reach via indirect interlocks? That is, if Director X from Company A and Director Y from Company B are both board members of Company C, an indirect interlock can be said to exist between A and B (e.g., Buch-Hansen, 2014a). While such an interlock is indirect as seen from the perspective of the companies, it is *direct* as seen from the perspective of the individuals (X and Y meet). As such, it constitutes a channel through which information can flow between companies.

Efforts to mute competition will typically involve the companies with the largest market shares (Harding & Joshua, 2003). It is thus of particular interest if – and if so, when and how – the *largest companies* in the German chemical industry – BASF, Bayer and Hoechst – were connected to one another via direct or indirect interlocks. It is worth noting that prior to the period we focus on here, the Big Three formed part of the gigantic IG Farben conglomerate, which emerged out of a highly cartelized industry through a merger between six chemical producers in 1925. After the war, IG Farben was broken up by the Allies, and BASF, Bayer and Hoechst were reconstituted as independent companies.

Another aspect of interest is the *duration* of ties connecting companies: the longer the boards of two companies are connected to one another, the more likely it is that the

relationship is characterised by mutual trust. Some research regards intra-sectoral interlocks that exceed individuals (two companies being connected through a succession of directors) as an indication that interlocks are used to mute competition (e.g., Koenig et al., 1979). A final aspect of the extent to which companies were connected concerns past affiliations. That is, in addition to ties connecting company boards through their current board members at a given point in time, ties created by past directors may also exist. If Director X is first affiliated with the board of Company A and then the board of Company B, then the boards of A and B will be connected as long as former colleagues of X are still board members of A and X is still a board member of B. Additionally, if one of X's former colleagues moves from A to a third company, C, this creates a tie between C and B. When assessing the strength of a network at any given point in time, the existence of such ties – we denote them *past ties* – should be taken into consideration alongside the current board interlocks.

SQ2: What type of board interlocks prevailed in the network?

Interlocks take different forms. In relation to dual board systems, such as the German system, a distinction can be made between primary and secondary board interlock ties (Carroll & Fennema, 2002). A *primary interlock* exists when a managing director of Company A sits on the supervisory board of Company B. Such ties are frequently a reflection of ownership, i.e., A owning a share in B (Windolf, 2002: 69). A *secondary interlock* comes into being when the same 'outsider' – such as a bank director – sits on two supervisory boards. While the literature considers secondary ties to be weaker than primary ties, secondary ties still constitute channels through which information can flow among companies.

Regarding secondary interlocks, we focus specifically on those created by trade unionists and bankers. The 1976 Codetermination Act stipulated an equal representation of employees and shareholders on the supervisory boards of companies with more than 2000 employees, meaning that half of the positions on the supervisory boards of Germany's large corporations are elected by the employees (on the codetermination system, see Gorton & Schmid, 2004). With this system, individuals from works councils and from external trade unions enter the supervisory board. The trade unionists can serve on multiple supervisory boards, hereby creating intra-sectoral board interlocks, which – like interlocks more

generally – serve as information channels. We are not aware of research that discusses this type of interlock, but since employees often feel the downsides of intense competition, it could well be in the interest of trade unionists to contribute to the inter-board dissemination of information that can mute the intensity of competition.

A substantial number of 'banker interlocks' – interlocks resulting from bank directors sitting on the supervisory boards of multiple industrial companies – is another distinguishing feature of *Deutschland AG*. Several studies, starting with the seminal works of Jeidels (1905) and Hilferding (1910), have focused on such interlocks. It has been noted that until the 1990s, the major German *Hausbanken* (principal banks) – Commerzbank, Deutsche Bank and Dresdner Bank – acted as key organisers of Germany's corporate networks. Höpner and Krempel attribute this role to the banks' multiple relationships to the industry: 'The banks were simultaneously supervisory board members, creditors, share owners, organizers of consortia and executors of the voting rights of dispersed shareholders' (2004: 343). Seeing themselves as 'the grand strategists of the nation's industry', the major banks developed broad long-term strategies for industries and sought to make individual industrial companies conform to these (Shonfield 1965: 261). Until the 1990s, 'the banks saw to it that members of *Deutschland AG* did not excessively compete with one another in the same markets, and they ensured that firms in good standing—that is, with a record of cooperation—did not unnecessarily fall victim to the vagaries of the market' (Streeck, 2009: 78). Indeed, the major banks typically considered it more important for industrial companies to service their debt than to generate high profits by outcompeting other companies. *Deutschland AG* moreover offered its members collective protection from pressure from shareholders and hostile takeovers by foreign companies (Streeck, 2009: 77). In the 1990s, as the major banks turned from being providers of patient capital to national industrial companies towards becoming internationally competitive investment banks, they became less interested in closely monitoring industrial companies, let alone in protecting them from market forces. Consequently, their managers were increasingly pulled from the supervisory boards of the German industry, resulting in a disintegration of *Deutschland AG* (Fohlin, 2007; Heinze, 2004). Addressing SQ2, we investigate how the chemical industry's board interlock network was affected by these wider changes.

SQ3: Did ties created via third-party venues significantly strengthen the network?

Third-party venues can serve as meeting places that connect companies that are not otherwise connected, *and* they can bring together managing (executive) directors of competing companies. That is, whereas a primary interlock brings together a managing director of Company A with the supervisory directors of Company B, third-party venues may serve as high-level meeting places where managing/executive directors of A and B have the opportunity to discuss common problems, exchange information and develop shared understandings. Thus, ties created via third parties may considerably strengthen a network. We track ties created by three types of third-party venues. First, as already mentioned under SQ1, we take indirect ties created via membership of the supervisory boards of other companies in the population into consideration. Second, since business associations have historically often played a role in efforts to constrain competition (Buch-Hansen, 2016; Harrington, 2006), we bring the managing board of the German chemical industry's main association, the *Verband der Chemischen Industrie* (VCI), into focus. Third, we zero in on the boards of the major banks. Research has found that in countries such as the Netherlands and Switzerland, bank boards served as meeting places for directors of industrial companies (Ginalski et al., 2014; Westerhuis, 2014). As regards the German case, Windolf (2014) finds that it was far more common for bankers to sit on the boards of non-financial companies than vice versa. His findings suggest that in Germany it was not typically the case that bank boards connected managers from competing industrial companies. In a similar vein, Ziegler et al. (1985: 106) observed the existence of a hierarchical bank-industry structure in Germany: 'executives of the three big banks sat on the supervisory boards of production companies, while the reverse occurred much less frequently'. We analyse whether these observations apply to chemical industry managers, taking into consideration both supervisory and advisory boards of the major banks. The advisory boards came into being as a reaction to changes in corporate governance legislation in 1965 which placed limits on the size of supervisory board as well as on how many such boards an individual could be a member of (Höpner & Krempel, 2004: 347).

2. Data and methods

A common approach in researching the history of corporate networks has been to map connections among the largest companies in an economy in two or more benchmark years (Lluch et al., 2019; Rinaldi & Spadavecchia, 2019; Windolf, 2014; see also Lemercier, 2015). While this approach can provide snapshot pictures of inter-sectoral networks, it does not allow for a precise mapping of the evolution of intra-sectoral networks. The present article thus takes a different approach. It utilises data on the board composition of the largest German chemical producers for each year over several decades in order to obtain a fine-grained perspective on how the network developed.[2] The challenge when selecting the largest producers in an industry while focusing on a long period of time is that new companies emerge, companies have different growth trajectories, and, in some cases, companies disappear as a consequence of mergers and acquisitions. To cope with this challenge, we selected companies from three ranking lists that included the top German chemical producers in the beginning, (roughly) the middle, and the end of the overall period (see Table 1), respectively. Companies appearing in *one or more* of these lists were selected (n=35). Data were collected on the compositions of their managing and supervisory boards for the duration of the company's existence as a public company within the overall 1950-2015 time window. Thus, if a company was included on, for example, the early list but not the later ones, data on its board composition would still be collected up until 2015 (if the company did not cease to exist). While all the companies were classified as chemical producers, their profiles were diverse. For instance, some were primarily oriented towards the production of pharmaceuticals, whereas others were primarily producers of basic chemicals. As such, different constellations of the companies were competitors in specific product markets. Also included in our data is the composition of the boards of the three major banks and the managing board of the industry's main business association, the VCI, from 1951-2015. The data were collected through archival works and stem primarily from the companies' annual reports and secondarily from the *Handbuch der Deutschen Aktiengesellschaften*. Additional materials were supplied by companies and the VCI.

[TABLE 1 HERE]

For the chemical companies, a total of 2796 board members, including 925 employee representatives, are included in the dataset.[3] A total of 105 board members were women. Information was recorded regarding each individual's position in the board (CEO/managing director/supervisory board chairman/supervisory board member/employee representative) and the period in which s/he took up a particular position in a given company. The data then enable us to identify the number and nature (primary, secondary) of the direct board interlocks existing among the companies in the population at any given point within the overall time window. For indirect board interlocks, the data gives us an incomplete picture inasmuch as directors from the chemical industry in many cases also met on the boards of non-chemical industrial companies. For this reason, we abstain from measures that rely on path lengths in a complete network, like centrality measures (Agneessens et al., 2017; Freeman, 1979), community detection (Fortunato, 2010), or core detection (Borgatti & Everett, 2000; Larsen & Ellersgaard, 2017). As the development of the German industry after the second world war is a result of relatively unique institutional developments, we do not specify more general generative network models such as ERGMS for this study.

Instead we rely on a parsimonious selection of network analytical concepts to analyse the company projection of the bi-partite affiliation network (Breiger, 1974). From social network analysis (Borgatti et al., 2009), we use the following basic concepts: *degree* (the number of nodes a node can reach in a single step), *reach* (the number of nodes a node can reach in two steps) and *component* (a set of nodes where there is a path between all nodes). Most measures of network integration, like density, are influenced by the size of the network, and as such it is difficult to find a single measure that can by itself answer whether a network is in decline or not. To establish how connected the companies (nodes) in the population were to one another (SQ1), we thus analyse across several measures that are less affected by the size of the network, such as average degree, the size of the largest component and the share of the network within reach. Here, *average degree* refers to the number of other companies in the population each company did on average interlock with. *Average reach* measures if companies on average had other companies within a short vicinity. To determine the number of past ties (see section 1), we introduce a 'reach with past' measure that takes past connections into account. Here we ask whether the directors of Company A have previously been 'board colleagues' with any of the directors in Company B.[4] We

moreover determine the share of companies that were included in the largest component, considering both present and past ties. Finally, we measure the duration of ties at the dyadic level (pairs of companies), before establishing the extent to which the Big Three were connected. To establish the type of interlocks that prevailed at different junctures (SQ2), we first calculate the relative proportion of primary and secondary interlocks for each year. Subsequently, we determine how many of the secondary interlocks in each year were created by trade unionists and bankers, more specifically managing directors and supervisory board chairmen from the big banks. Finally, to establish whether ties created via third-party venues (other than boards of companies in the population) significantly strengthened the network (SQ3), we determine the extent to which the supervisory and advisory boards of the big banks and the VCI served as meeting places that created ties between companies that were not otherwise connected.

When measuring the connectivity of the network, we consistently use conservative measures, i.e., measures that underestimate rather than overestimate the density of the network. Including only the top 35 companies, we are excluding thousands of boards that could potentially connect the largest chemical companies. Additionally, we do not look into public commissions, private clubs, alumni societies, etc., which all might integrate directors from chemical companies (Barnes, 2017; Larsen & Ellersgaard, 2018). The benefit of looking almost exclusively at the boards of chemical companies is that they constitute venues in which the strategies specifically of such companies are discussed.

3. To what extent were the companies connected?

This section concerns the extent to which the companies in the population were connected through board interlocks at different junctures (SQ1). With the exception of one company (Stada), all the companies were at some point interlocked to another company in the population.[5] The number of active board interlocks (ties) escalated rapidly at the very beginning of the period covered here, from 12 in 1950 to 36 in 1953 (Figure 1, top left). This increase happened in the context of a growth in the number of active companies (nodes) as companies that had been under the control of the Allies were reconstituted as independent entities (Figure 1, top right). N remains relatively stable until the 1990s, after which it begins

to decline as some companies in the population disappeared due to mergers and acquisitions. For instance, in 1999 Hoechst merged with French company Rhône-Poulenc and became Aventis. The number of board interlocks grew incrementally and unevenly from the mid-1950s and into the early 1990s, with spikes in 1970 and 1988.[6] The 1970s and 1980s were the decades that witnessed the largest amount of interlocks. From 1993 to 2010, the number of active board interlocks declined from 40 to 14, after which it increased somewhat.

[FIGURE 1 HERE]

Considering the share of companies that were part of the largest component, it is clear that the network was dense throughout the period. For 43 of the total years we cover, more than 70% of the companies (active nodes) were part of the largest component and only at one point did the share drop below 50% (Figure 1, second row left, see Appendix 1 for plots of each year). When past ties are considered as well, the share of companies in the component reaches 90% for two years (1985-1986) (Figure 1, second row left). In both of these years and in later years, such as 1995 and 2007, the span between present and past ties is substantial, indicating the existence of more connections between the boards than the number of present ties suggests. In the end of the period, the average company was able to reach 30% of all companies with present ties and 44% when past ties were included (Figure 1, second row right). If we look at the entire period, past ties on average add 7% to the average reach, which indicates a moderate but substantial influence of the past connections in an already dense network. While we see a general decline in the number of nodes and ties in the network, the average reach and the share in the largest component show no strong declining trend (Figure 1, bottom left). Here, we find a decline in absolute activity, but not in the relative measures.

As for the duration of ties, Figure 2 shows what companies were directly connected via direct interlocks and for how long. For instance, the first row shows that BASF connected with 22 of the 34 other companies in the population. For 6 of these companies, the connections lasted for 20 years or more (yellow). In total, 46% of the dyads were directly connected for 10 or more years and 15% of dyads lasted 20 or more years. In most cases, these interlocks

exceeded individual directors, in some cases involving that a new interlock was created when the previous one ended due to the resignation or death of a director (for a discussion of the reconstitution of such 'broken ties', see e.g., Palmer, 1983).

[FIGURE 2 HERE]

It is worth noting that BASF did not at any point directly connect with the industry's other two giants, Bayer and Hoechst. In fact, 1998 – when the boards of Bayer and Hoechst briefly connected through trade unionist Werner Bischoff – was the only point at which a direct tie existed between the boards of the Big Three. Crucially, however, the Big Three connected to one another via *indirect interlocks*. That is, their directors met on the boards of other chemical companies in the population, such as Cassella, Kali und Salz, and Linde. In fact, *for 34 out of 48 possible years BASF and Hoechst connected in this way, Bayer and Hoechst connected for 39 of 48 years, and BASF and Bayer connected for 46 of 64 years* (see also Appendix 2).

4. What was the nature of the board interlocks?

Turning to the nature of the board interlocks connecting the companies (SQ2), it can be noted that, unsurprisingly, secondary interlocks were more common than primary ones throughout the 1950-2015 period (Figure 3, top left). Some prolonged periods – such as 1950-1957 and 1969-1979 – witnessed growth in the share of *primary interlocks*, indicating a strengthening of the network.[7] Overall, the 1979-2009 period was characterised by a gradual, albeit uneven, decline in the number of primary interlocks. A substantial part of the primary interlocks among the companies in our population are likely to reflect ownership relations. That is, for most of the period covered here, it was not unusual for non-financial companies to own a share in other non-financial companies, including companies in the same sector.

[FIGURE 3 HERE]

The board interlock history of chemical and pharmaceutical company Cassella is illustrative in this respect (see also Appendix 2). After the war, Cassella was among a group of companies that 'were left with a measure of independence pending future reorganization' (Aftalion, 2001: 243). In 1952, the first post-war year that Cassella had independent boards, it interlocked with two companies from the population, Chemische Werke Albert and Süd Chemie. In the mid-1950s, the Big Three each acquired 25.1% of Casella and simultaneously Julius Overhoff, Otto Bayer, and Emil Thiel of the managing boards of BASF, Bayer and Hoechst, respectively, became supervisory board members of Cassella. In 1970, Hoechst bought the Cassella shares of BASF and Bayer, at which stage the interlocks between the latter two companies and Cassella were terminated. Hoechst had multiple directors on Cassella's supervisory board until the company was integrated into Hoechst in 1995. Aside from exemplifying how managers of the Big Three met on the supervisory boards of the other chemical companies, the Cassella case also shows the existence of a clear overlap between primary interlocks and ownership relations.

Overall, the observed long-term decline in primary interlocks after the end of the 1970s is likely to reflect that it became less common for chemical companies to own a stake in other chemical companies. A contributing factor was a reform passed in 2000, which made it attractive for companies to sell their shareholdings in other companies (Streeck, 2009: 79; see also O'Sullivan, 2003).[8] More generally, a series of changes in the German corporate governance system from the 1990s onwards, many of which made the system more shareholder-oriented, impacted the network. Most importantly, the German Corporate Governance Code, introduced in 2002 and subsequently amended on an annual basis, stipulates that a managing director should not accept more than three supervisory board mandates (Regierungskommission, 2015). Previously, a number of managers created coherence in the network by serving on the supervisory boards of multiple chemical companies. Karl Winnacker, CEO and then chairman of the supervisory board of Hoechst, is a case in point: during the 1960s and 1970s, he was – in different, yet often overlapping periods – a member of the boards of five other chemical companies, a member of the VCI managing board and of the Dresdner Bank supervisory/advisory boards. Big linkers such as this were in a particularly strong position to disseminate information in the industry's network and are almost certain to have been of considerable importance in terms of its ability to

control competition (on big linkers, see e.g., de Jong et al., 2019).

Regarding the nature of secondary interlocks, many of them were, particularly in the beginning of the period, created by either bank managers or chairmen of the supervisory board of banks (Figure 3, top right). In 1954, more than 50% of all interlocks (primary and secondary) among the chemical companies were banker interlocks (Figure 3, bottom left). Such interlocks were, in other words, crucial to the integration of the network during this period: had the bankers not been there, no less than 11 chemical companies would have dropped out of the largest component (Figure 3, bottom right). The extent of their involvement in the network reflects that the major banks wielded significant power over the German industry. However, they did so less through ownership than through the proxy voting system, which allowed them to vote at shareholders meetings on behalf of shares deposited in the banks. In 1986, for example, none of the three major banks owned stocks of more than 4% in the chemical industry's Big Three, yet together they voted with 54.50%, 51.68% and 63.48% of the shares of Bayer, BASF and Hoechst, respectively (Baums, 1992: 524-525). The system contributes to explain why long-term board interlocks existed between the major banks and the Big Three.

In the second part of the 1950s and the 1960s, the share of board interlocks created by bankers plummeted, reaching 12.5% in 1970. At this point, the bankers contributed little to the coherence of the network: only one chemical company would have been disconnected from the main component in the absence of the bankers. Subsequently, as the share of banker interlocks grew, they once again came to significantly enhance the integration of the network in the 1970s. In the first part of the 1990s, as the overall number of interlocks dropped, the share of banker interlocks once again rose sharply before falling again. Seen over the entire period, the share of banker interlocks was on a downward trajectory. However, these interlocks never disappeared, and in some periods they contributed significantly to integrating the board interlock network.

After the adoption of the 1976 Codetermination Act, trade unionists entered the scene as interlockers. According to our data, the first trade union interlocks appeared in 1978 and subsequently accounted for a substantial share (approximately 10-20%) of all interlocks until

2006. Then, in the context of the aforementioned decline in the overall number of board interlocks, the share of interlocks involving unionists increased substantially, culminating at 47% in 2013 (Figure 3, bottom left). Trade unionists thus came to play an important integrative role in the network. In 2000, 7 companies would have dropped out of the largest component had it not been for the trade unionist interlocks (Figure 3, top right). One trade unionist especially had an integrative role in the network towards the end of the period, namely, Michael Vassiladis of the IG Bergbau, Chemie, Energie. In 2013, he was a member of the supervisory boards of BASF, Evonik, Henkel, and Kali und Salz, giving him the largest number of board memberships of any individual in our population at this juncture. We interpret it as a weakening of the network that unionists became important to its coherence towards the end of the period. Nevertheless, it would be unwarranted to rule out the possibility that these trade unionist interlocks play a role in muting competition in the industry with a view to preserve jobs. This matter deserves scrutiny in future research.

5. Did the major banks and the VCI constitute important meeting places?

Next, we turn our attention to the extent to which the boards of Deutsche Bank, Commerzbank and Dresdner Bank, as well as the managing board of VCI (the industry association), constituted meeting places for managers in the chemical industry (SQ3). The data show that both the supervisory and advisory boards of the three major banks served as meeting places for chemical directors, hereby strengthening the industry's already close-knit network. Counting only the individuals at the top of the leadership hierarchy in the chemical companies – CEOs, managing directors and supervisory board chairmen – we find that over the 1953-1998 period they connected between 9 and 15 chemical companies through their bank board memberships (Figure 4).

[FIGURE 4 HERE]

Although the majority of these companies were already connected via board interlocks, in most years new connections were created through the bank boards. In some years, a remarkable number of high-level chemical industry directors met on bank boards. The

advisory board of Dresdner Bank was particularly important: in some years it had members that connected as much as 9 chemical companies from our population (Figure 5). Towards the end of the time window, the banks became less important connectors of companies in the chemical industry because they phased out their advisory boards (at least in their previous form), and because Dresdner Bank ceased to exist when acquired by Commerzbank in 2009.

[FIGURE 5 HERE]

Throughout the 1951-2015 period, the VCI constituted another important meeting place in the chemical industry. Over time it connected a large number of companies that were not otherwise connected. In most years, its managing board consisted of four individuals. Of the 40 men that were – for varying durations of time – members of the VCI managing board, the vast majority were CEOs. While 13 different companies were at some point 'represented' on the VCI board, 25 members (out of the 40) came from the Big Three and Degussa/Evonik. Overall, the VCI board constituted a meeting place for top managers from the German chemical industry, especially its largest companies.

The importance of the banks and the VCI as meeting places can also be illustrated by again considering the connections among the Big Three. As noted above, these companies were connected via indirect interlocks (through the boards of other chemical companies) in most of the time window. However, when we factor in the boards of the major banks and the VCI, the number of years in which BASF and Hoechst were connected increases from 34 to 40 years (out of a possible 48), Bayer-Hoechst increases from 39 to 46 years (out of a possible 48) and BASF-Bayer increases from 46 to 62 years (out of a possible 64).

6. Discussion of main findings

A major trend in research on (corporate) networks these years is to utilise big data to map huge networks (Heemskerk et al., 2018). With this article, we have taken a small step in the

opposite direction by studying the long-term year-on-year evolution of network ties existing among a relatively small population of companies. The benefits of taking this approach are that both past ties and developments that fall under the radar when focusing on one year – or a few benchmark years – become visible. By documenting the trajectory of a corporate network in one particular industry while taking various meeting places into account, our article sheds some new light on important aspects of *Deutschland AG* and suggests that, in some important respects, Germany's coordinated form of capitalism was even more coordinated than has been recognised. In the following we relate our findings to existing research on Germany's corporate networks, as well as scholarship on the chemical industry.

Previous research, focusing on the density of Germany's overall board interlock network in selected benchmark years, finds that 'after World War II, it is in permanent decline until, at the beginning of the twenty-first century, [it] has disintegrated almost completely' (Windolf, 2014: 72). Some works note that the density of Germany's corporate network began to substantially decrease from around the mid-1980s onwards, contributing to the wider unravelling of Germany's cooperative form of capitalism in the second half of the 1990s (Beyer & Höpner, 2003; Höpner & Krempel, 2004). Our data on the chemical industry do not show that its board interlock network was in a state of permanent decline in the 1950-2015 period, or that it ended up completely disintegrating. We find that the absolute number of ties declined (which was however related to a corresponding decline in the number of companies) and that the overall tendency since the 1980s has been a declining proportion of primary ties. While this represents a weakening of the network, the average reach and the share in the largest component show no strong declining trend. This finding is noteworthy given the literature on the fracturing of *Deutschland AG*.

Themes in this literature are the effects of globalisation and intensified transnational competition. These factors, in the words of Streeck (2009: 87), 'devalued the security that could be gained from mutual protection at the national level. Stronger firms in particular began to feel that they had no choice but to seek success in competition rather than rely on protection'. The internationalisation of markets is certainly likely to have contributed to the weakening of the board interlock network in the German chemical industry. While internationalisation is far from a new phenomenon in the chemical industry (Martinelli, 1991:

12), the period focused on here witnessed an overall decline in the importance of domestic markets, while foreign markets became increasingly important to the industry (Marx 2019: 6).[9] If intra-sectoral board interlocks are mechanisms that, for instance, serve to control competition, then companies can, ceteris paribus, be expected to react to internationalisation by growing the proportion of cross-border ties at the expense of intra-national ties. Based on the data used in this article, we cannot gauge the extent to which this development occurred. However, a study of ties connecting the 24 largest European chemical companies from 1960-2000, including 7 German companies (all of which are included in the data used in the present article), found that over time an increasing proportion of board interlocks connected companies across borders (Buch-Hansen & Henriksen, 2019). Especially in the context of the efforts of European governments to complete the common market in the 1980s and 1990s, chemical companies rapidly grew the number of interlocks and an unprecedented proportion of these were cross-border interlocks. By 2000, many of these interlocks had, however, been terminated as companies opted for other means of exercising market control. As such, even though Europe remained the German chemical industry's by far largest export market at the end of the period covered in the present article (GTAI, 2018), a very dense network should not be expected to have existed in the European chemical industry at that point.

As noted in the first section, various studies suggest or give the impression that the boards of the major German banks did not typically serve as meeting places for managers of competing industrial companies. Our findings strongly contradict this suggestion: the advisory and supervisory boards of Deutsche Bank, Commerzbank and Dresdner Bank *did*, in many years, serve as important meeting places for top-level directors from competing chemical companies, directors that were in many cases not already connected through the other forms of ties considered here. There is no question that these bank boards served other functions than overseeing the operation of a specific bank. As one director put it when being transferred from the Dresdner Bank's supervisory board to its new advisory board in 1966: 'I don't mind whether or not we call ourselves supervisory board members, as long as we can meet routinely to discuss our economic problems' (cited in Höpner & Krempel, 2004: 347). Commenting on the close connections existing between the boards of Hoechst, Commerzbank and Dresdner Bank in the 1960s, Marx (2017: 14) writes that they were

based less on capital ties than 'on a relationship of trust between banks and industry and the function of the bank as a broker of information'. Our findings are consistent with – and substantiate – the suggestion that the major banks were well positioned to act as brokers of information in the chemical industry. Banker interlocks created channels between chemical companies that did not directly connect via other board interlocks. Especially in the very beginning of the period, when the board interlock network was in the process of being (re)built after the Allies' occupation of Germany, banks played a significant role in integrating the boards of the chemical industry.

Many studies highlight the significance of the withdrawal of bank managers from the supervisory boards of industry from around the mid-1980s for the unravelling of *Deutschland AG*. Our data show that the banks indeed became less involved in the chemical industry's corporate network, by creating, for instance, a smaller share of interlocks towards the end of the period than they had done in most of the previous years. Nevertheless, we find that the largest decline in the share of banker interlocks happened in the 1950s, whereas neither the 1980s nor 1990s were periods witnessing major declines in such interlocks.

Studies of Germany's wider board interlock network have suggested that it did not impede competition among large industrial competitors, as these were not connected through direct board interlocks. For instance, Ziegler et al. (1985: 100) observe that, in 1976 '[n]o interlocks occurred between commercial banks and among competing production companies' within the dense core of the German corporate network.[10] They took the absence of these ties as a sign that competition was not precluded. Our findings confirm that the Big Three in the chemical industry were indeed, with one minor exception, at no point connected through direct interlocks over the 1950-2015 period. Importantly, however, we find that BASF, Bayer and Hoechst *were* closely connected to one another through various other meeting places – the boards of other chemical companies, banks and the VCI – in almost the entire period. This finding underscores the importance of including in the analysis ties beyond direct interlocks.

Research on the chemical industry has noted that, by developing distinct portfolios, the Big Three to some extent avoided aggressive competition with one another. They did this by

means of ‘informal market-sharing’ (Ilgen, 1983), most notably in the context of the downturn in the German chemical industry caused by the oil crisis in the 1970s. The strategy of the Big Three ‘was to engage in an informal rationalization of the industry that would permit each to protect traditional strengths’ (1983: 673). At this juncture, then, BASF came to focus mainly on bulk chemicals and fertilisers, Bayer on specialty chemicals and Hoechst on synthetic fibres and pharmaceuticals. It is reasonable to assume that this effort to mute competition was premised on the existence of network connections among managers of the Big Three – including the type of connections we have documented in this article. Although the Big Three moved in different directions as a result of informal market sharing, ‘none curtailed activity altogether in the sectors designated for the others’ (Ilgen 1983: 673). It should thus not be concluded that they were different to the extent where ‘there was little overlap that gave reason for elaborate collusive action’ (Wengenroth 2007: 141). The Big Three remained competitors in some product markets, at least throughout most of the period covered here. Indeed, their memberships in some of the same cartels is clear evidence of this: most notably, the three companies were all members of a cartel that existed among the major European producers of low density polyethylene from 1976 to 1984 (Commission, 1988).[11]

Conclusion: The chemical brothers

In *Capital*, Marx (1966: 253) wrote that competition can become like ‘a fight among hostile brothers’. In the present article, we have focused on a group of chemical companies that – in different constellations – were competitors. Throughout most of the 1950-2015 period, the bulk of them also formed part of a comprehensive intra-sectoral board interlock network. This network, we contend, served as a mechanism through which competition could be regulated to avoid excessive hostility among “the chemical brothers”.

Tracking the evolution of the network, we find that its strength changed considerably over the 1950-2015 period. The network was constructed in the first half of the 1950s with the heavy involvement of bankers. The largest number of interlocks existed in the 1970s and 1980s, which can be considered as the heyday of the network. The considerable extent to

which the companies were connected becomes particularly clear when past ties and meeting places in the form of third-party boards within the industry, the VCI and the major banks are also taken into account. While fluctuating, the largest share of primary interlocks existed during the first three decades. From the 1980s onwards, the share of these interlocks gradually fell, indicating a weakening of the network before the 1990s, when the overall number of ties began to fall. During this decade, the number of chemical companies that had directors on bank boards also plummeted. Trade unionist interlocks became important to the coherence of the network from 2000 onwards, overall indicating a weakening of the network as a mechanism for muting competition.

Shonfield once observed that 'no businessman is an island' and that 'German institutions and habits […] produce a climate which favours industrial collaboration' (1965: 247, 246). The network we have scrutinised in this article has been an important component in an infrastructure bringing together German businessmen, facilitating a collaborative climate. It should be acknowledged that while a strong intra-sectoral network may have powers enabling it to limit competition, it is another matter whether – and if so to what extent – those powers are exercised. Our goal has been to assess the (changing) strength of the board interlock network in the German chemical industry; not to present 'smoking guns' to prove how specific constellations of companies used it to mute competition. Future research could attempt to correlate our findings with other data to gauge the intensity of competition at various junctures. However, doing so is inherently difficult, as no straightforward or accurate measure of competition exists. In fact, the extent to which competitors connect through various forms of networks may be the best – albeit certainly imperfect – measure of the extent to which competition in an industry is muted.

Acknowledgements

We would like to thank the reviewers, the editor, colleagues at the Department of Organization and the former Department of Business and Politics (Copenhagen Business School) as well as participants in the corporate networks session at the Third European Conference on Social Networks in Mainz in September 2017 for many great comments. We are moreover grateful to Martina Maasjosthusmann at the Wirtschaftsarchiv, Wirtschafts- und Sozialwissenschaftliche Fakultät, Universität zu Köln and to the organisations that provided us with annual reports and other information.

References

Aftalion, F. (2001). *A History of the International Chemical Industry*. Chemical Heritage Press.

Agneessens, F., Borgatti, S. P., & Everett, M. G. (2017). Geodesic Based Centrality: Unifying the Local and the Global. *Social Networks*, *49*, 12–26.

Barnes, R. C. (2017). Structural Redundancy and Multiplicity within Networks of US Corporate Directors. *Critical Sociology*, *43*(1), 37–57.

Baums, T. (1992). Corporate Governance in Germany: The Role of the Banks. *The American Journal of Comparative Law*, *40*(2), 503–526.

Beyer, J., & Höpner, M. (2003). The disintegration of organised capitalism: German corporate governance in the 1990s. *West European Politics*, *26*(4), 179–198.

Borgatti, S. P., & Everett, M. G. (2000). Models of Core/Periphery Structures. *Social Networks*, *21*(4), 375–395.

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network Analysis in the Social Sciences. *Science*, *323*, 892–895.

Breiger, R. L. (1974). The Duality of Persons and Groups. *Social Forces*, *53*, 181–190.

Buch-Hansen, H. (2014a). Interlocking directorates and collusion: An empirical analysis. *International Sociology*, *29*(3).

Buch-Hansen, H. (2014b). Social network analysis and critical realism. *Journal for the Theory of Social Behaviour*, *44*(3), 306–325.

Buch-Hansen, H. (2016). *Karteller - Afsløringen af aftalt spil i dansk erhvervsliv*. Gyldendal Business.

Buch-Hansen, H., & Henriksen, L. F. (2019). Toxic ties: corporate networks of market control in the European chemical industry, 1960–2000. *Social Networks*, *58*, 24–36.

Bühlmann, F., Beetschen, M., David, T., Ginalski, S., & Mach, A. (2017). Elites in Switzerland: the rise and fall of a model of elite coordination. *Tempo Social*, *29*(3), 181–199.

Carroll, W. K., & Fennema, M. (2002). Is There a Transnational Business Community? *International Sociology*, *17*(2), 393–419.

Chandler, A. D. (1990). *Scale and Scope. The Dynamics of Industrial Capitalism*. Harvard University Press.

Chandler, A. D. (2005). *Shaping the Industrial Century*. Harvard University Press.

Commission. (1988). *Commission decision - LdPE, IV/31.866*. European Commission.

David, T., & Westerhuis, G. (Eds.). (2014). *The Power of Corporate Networks. A Comparative and Historical Perspective*. Routledge.

de Jong, A., Fliers, P. T., & Westerhuis, G. (2019). Exceptional big linkers: Dutch evidence from the 20th century. *Business History*, *0*(0), 1–31.

Eichenberger, P., & Ginalski, S. (2016). 'Si vis pacem, para bellum'—the construction of business cooperation in the Swiss machinery industry. *Socio-Economic Review*, *15*(3), 615–635.

Elhauge, E. (2015). Horizontal Shareholding. *Harvard Law Review*, *129*, 1267–1317.

Fligstein, N. (2001). *The Architecture of Markets*. Princeton University Press.

Fohlin, C. (2007). The History of Corporate Ownership and Control in Germany. In R. K. Morck (Ed.), *A History of Corporate Governance around the World* (pp. 223–282). University of Chicago Press.

Fortunato, S. (2010). Community detection in graphs. *Physics Reports*, *486*(3–5), 75–174.

Freeman, L. C. (1979). Centrality in Social Networks Conceptual Clarification. *Social*

Networks, *1*(3), 215–239.
Ginalski, S., David, T., & Mach, A. (2014). From National Cohesion to Transnationalization. The Changing Role of Banks in the Swiss Company Network, 1910-2010. In T. David & G. Westerhuis (Eds.), *The Power of Corporate Networks* (pp. 107–124). Routledge.
Gorton, G., & Schmid, F. A. (2004). Capital, Labor, and the Firm: A Study of German Codetermination. *Journal of the European Economic Association*, *2*(5), 863–905. https://doi.org/10.1162/1542476042782260
GTAI. (2018). *The Chemical Industry in Germany*. Germany Trade & Invest.
Harding, C., & Joshua, J. (2003). *Regulating Cartels in Europe: A Study of Legal Control of Corporate Delinquency*. Oxford University Press.
Harrington, J. E. (2006). How Do Cartels Operate? *Foundations and Trends in Microeconomics*, *2*(1), 1–105.
Heemskerk, E., Young, K., Takes, F. W., Cronin, B., Garcia-Bernardo, J., Henriksen, L. F., Winecoff, W. K., Popov, V., & Laurin-Lamothe, A. (2018). The promise and perils of using big data in the study of corporate networks: problems, diagnostics and fixes. *Global Networks*, *18*(1), 3–32.
Heinze, T. (2004). Dynamics in the German system of corporate governance? Empirical findings regarding interlocking directorates. *Economy and Society*, *33*(2), 218–238. https://doi.org/10.1080/03085140410001677139
Hilferding, R. (1910). *Das Finanzkapital. Eine Studie über die jüngste Entwicklung des Kapitalismus*. Verlag der Wiener Volksbuchhandlung.
Höpner, M., & Krempel, L. (2004). The Politics of the German Company Network. *Competition & Change*, *8*(4), 339–356.
Ilgen, T. L. (1983). “Better living through chemistry”: the chemical industry in the world. *International Organization*, *37*(4), 647–680.
Jacobs, M. E. (2014). Combating Anticompetitive Interlocks: Section 8 of the Clayton Act as a Template for Small and Emerging Economies. *Fordham International Law Journal*, *37*(3), 644–686.
Jeidels, O. (1905). *Das verhältnis der deutschen Grossbanken zur Industrie mit besonderer Berücksichtigung der Eisenindustri*. Duncker & Humblot.
Jones, G., & Lubinski, C. (2014). Making ‘Green Giants’’: Environment sustainability in the German chemical industry, 1950s–1980s.’ *Business History*, *56*(4), 623–649.
Koenig, T., Gogel, R., & Sonquist, J. A. (1979). Models of the Significance of Interlocking Corporate Directorates. *American Journal of Economics and Sociology*, *38*(2), 173–186.
Larsen, A. G., & Ellersgaard, C. H. (2017). Identifying power elites—k-cores in heterogeneous affiliation networks. *Social Networks*, *50*, 55–69.
Larsen, A. G., & Ellersgaard, C. H. (2018). The inner circle revisited: the case of an egalitarian society. *Socio-Economic Review*, *16*(2), 251–275.
Lemercier, C. (2015). Taking time seriously. How do we deal with change in historical networks? In M. Gamper, L. Reschke, & M. Düring (Eds.), *Knoten und Kanten III. Soziale Netzwerkanalyse in Geschichts- und Politikforschung* (pp. 183–211). Transcript Verlag.
Lluch, A., Rinaldi, A., Salvaj, E., & Vasta, M. (2019). Directors and syndics in corporate networks: Argentina and Italy compared (1913–1990). *Business History*, *61*(4), 603–628.
Martinelli, Al. (1991). Introduction. In A Martinelli (Ed.), *International Markets and Global Firms*. SAGE Publications.

Marx, C. (2019). Between national governance and the internationalisation of business. The case of four major West German producers of chemicals, pharmaceuticals and fibres, 1945–2000. *Business History*, *5*, 833–862.
Marx, C., & Reitmayer, M. (2019). Introduction: Rhenish capitalism and business history. *Business History*, *61*(5), 745–784.
Marx, K. (1966). *Capital, Vol III*. Progress Publishers.
Mizruchi, M. S. (1996). What do Interlocks do? An Analysis, Critique, and Assessment of Research on Interlocking Directorates. *Annual Review of Sociology*, *22*, 271–298.
O'Sullivan, M. (2003). The political economy of comparative corporate governance. *Review of International Political Economy*, *10*(1), 23–72. https://doi.org/10.1080/0969229032000048899
Palmer, D. (1983). Broken Ties: Interlocking Directorates and Intercorporate Coordination. *Administrative Science Quarterly*, *28*(1), 40–55.
Prell, C. (2012). *Social Network Analysis*. Sage.
Regierungskommission. (2015). *German Corporate Governance Code (as amended on May 5, 2015)*.
Rinaldi, A., & Spadavecchia, A. (2019). The banking-industry relationship in Italy: large national banks and small local banks compared (1913–1936). *Business History*, *0*(0), 1–18.
Rubio-Mondéjar, J. A., & Garrués-Irurzun, J. (2016). Economic and Social Power in Spain: corporate networks of banks, utilities and other large companies (1917–2009). *Business History*, *58*(6), 858–879.
Sapinski, J. P., & Carroll, W. K. (2018). Interlocking directorates and corporate networks. In A. Nölke & C. May (Eds.), *Handbook of the International Political Economy of the Corporation* (pp. 45–60). Edward Elgar.
Schnyder, G., & Wilson, J. F. (2014). The Structure of Networks. The Transformation of UK Business, 1904-2010. In T. David & G. Westerhuis (Eds.), *The Power of Corporate Networks2* (pp. 48–65). Routledge.
Schröter, H. G. (1997). Fields of Competition and of Cooperation: Cartel Structures in the International Chemical Industry. In H. Pohl (Ed.), *Competition and Cooperation of Enterprises on National and International Markets* (pp. 35–56). Franz Steiner Verlag Stuttgart.
Seldeslachts, J., Newham, M., & Banal-Estanol, A. (2017). Changes in common ownership of German companies. *DIW Economic Bulletin*, *30*, 303–311.
Shonfield, A. (1965). *Modern Capitalism*. Oxford University Press.
Streeck, W. (2009). *Re-forming capitalism. Institutional Change in the German Political Economy*. Oxford University Press.
Useem, M. (1984). *The Inner Circle. Large Corporations and the Rise of Business Political Activity in the US and UK*. Oxford University Press.
Van Veen, K., & Elbertsen, J. (2008). Governance Regimes and Nationality Diversity in Corporate Boards: A Comparative Study of Germany, the Netherlands and the United Kingdom. *Corporate Governance: An International Review*, *16*(5), 386–399.
Wengenroth, U. (2007). The German Chemical Industry after World War II. In L. Galambos, T. Hikino, & V. Zamagi (Eds.), *The Global Chemical Industry in the Age of the Petrochemical Revolution2* (pp. 141–167). Cambridge University Press.
Windolf, P. (2002). *Corporate Networks in Europe and the United States*. Oxford University Press.
Windolf, P. (2014). The Corporate Network in Germany, 1896-2010. In T. David & G.

Westerhuis (Eds.), *The Power of Corporate Networks*. Routledge.
Winnacker, K. (1972). *Challenging Years. My Life in Chemistry*. Sidgwick & Jackson.
Ziegler, R., Bender, D., & Biehler, H. (1985). Industry and Banking in the German Corporate Network. In F. N. Stokman, R. Ziegler, & J. Scott (Eds.), *Networks of Corporate Power* (pp. 91–111). Polity Press.

Endnotes

[1] A board interlock occurs when a director simultaneously serves on the boards of two companies.
[2] The data that support the findings of this study are openly available in [xxxx] at http://doi.org/[doi], reference number [reference number].
[3] In reality, the number of employee representatives was somewhat higher: prior to the 1990s, it does not appear from the annual reports of some of the companies in which supervisory board members were employee representatives. In cases where it could not be established whether an individual was an employee representative, s/he was categorized simply as a supervisory board member.
[4] This measure can be seen to illustrate the usefulness of network analysis as a method for getting beneath surface appearances (Buch-Hansen, 2014b).
[5] There can be various reasons as to why Stada did not interlock with other companies in the population. An important part of the explanation is to be found in the company's rather unusual history. Stada has its roots in a pharmacists' cooperative founded in 1895. It became a corporation (limited company) in 1970, yet only pharmacists and company employees were allowed as shareholders until 1993. The type of ownership relations that often exist in parallel with board interlocks were thus ruled out for most of the period covered here, including the decades during which the chemical industry's board interlock network emerged and consolidated. Moreover, the company appears to have had a strongly international outlook from the mid-1980s onwards. Against this background, it can be hypothesized that intra-sectoral board interlocks in the German market were deemed less attractive than interlocks with companies in foreign markets. To assess this hypothesis, however, additional data and research are required.
[6] Here we do not take multiple ties into consideration, i.e., that some company dyads were in some years connected through more than one tie.
[7] Towards the very end of the time window, at which point the number of ties was low compared to earlier, the share of primary interlocks also grew.
[8] In fact, ownership patterns in this and other industries have changed fundamentally in recent times. A 2017 report published by the German Institute for Economic Research reveals that the world's largest institutional investor, BlackRock, has become heavily involved in the German chemical industry (Seldeslachts et al., 2017). Some scholars argue that such common ownership is a mechanism that serves to reduce competition (Elhauge, 2015).
[9] Related to the issue of internationalisation, research has found that one factor causing the thinning of national board interlock networks is the large increase in foreign directors from the 1980s onwards (a case in point is Switzerland, see Bühlmann et al., 2017; Ginalski et al., 2014: 118). Such directors typically do not hold multiple boards in a single country. Our

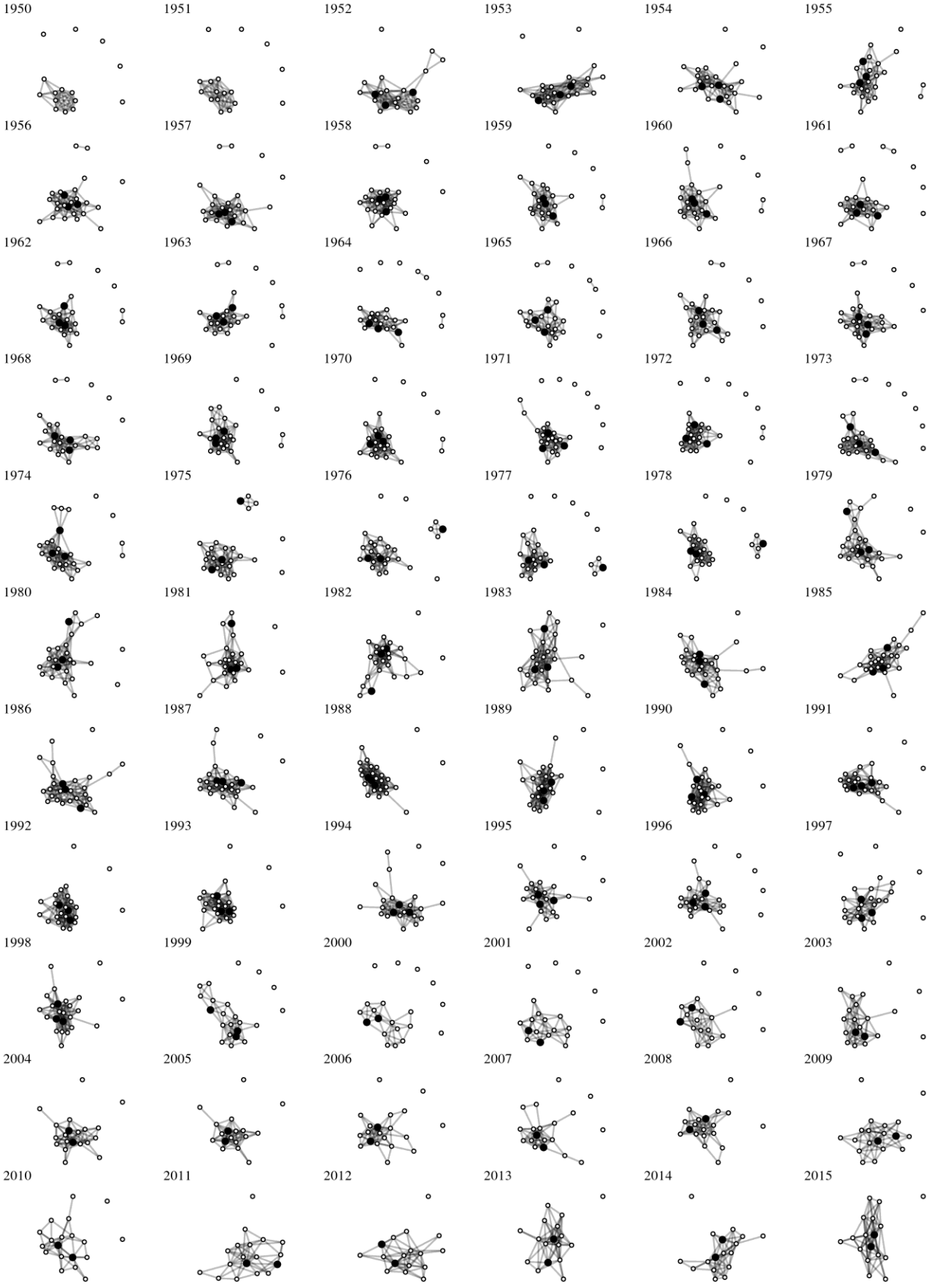
data do not include information on the nationality of directors, and as such we cannot assess the hypothesis that the observed developments were partly caused by an increase of foreigners. It can be noted, however, that van Veen and Elbertsen (2008) found a sample of German companies to have a significantly lower number of foreigners on their boards than had Dutch and British companies.

[10] The exception was the steel industry, in which large competitors were linked via board interlocks.

[11] Other forms of ties than those we have focused on here existed between the Big Three. For instance, Aftalion (2001: 246-247) notes that in the 1950s and 1960s the managing boards of the Big Three 'were headed by eminent chemists – Professors Wurster at BASF, Haberland at Bayer, and Winnacker at Hoechst – who knew one another and held one another in high esteem. […] these leaders were careful not to compete too relentlessly with each other' (see also Winnacker, 1972: 101).

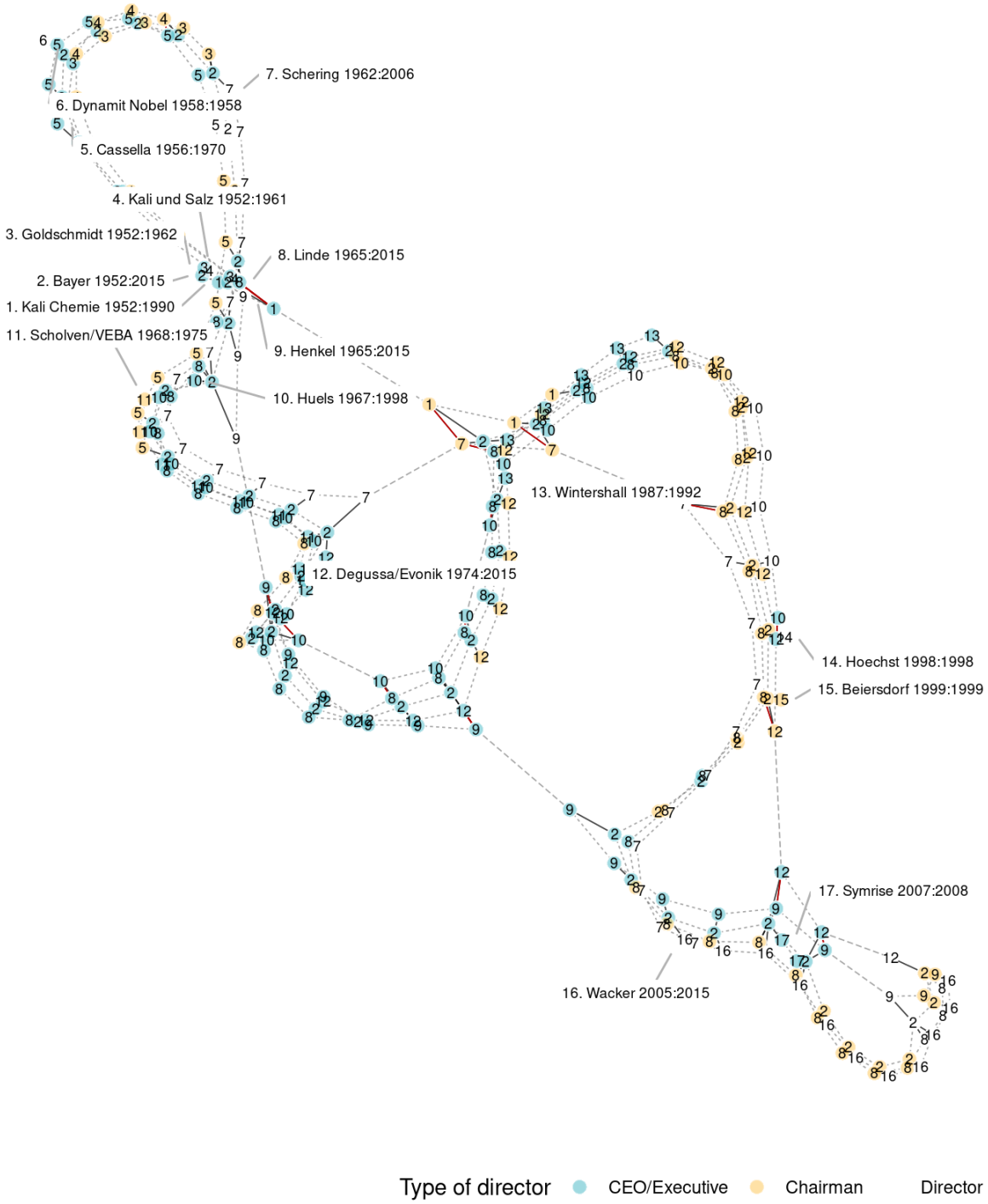
Appendix 1: Board interlocks between German chemical companies

Black dots are the Big Three: BASF, Bayer and Hoechst.

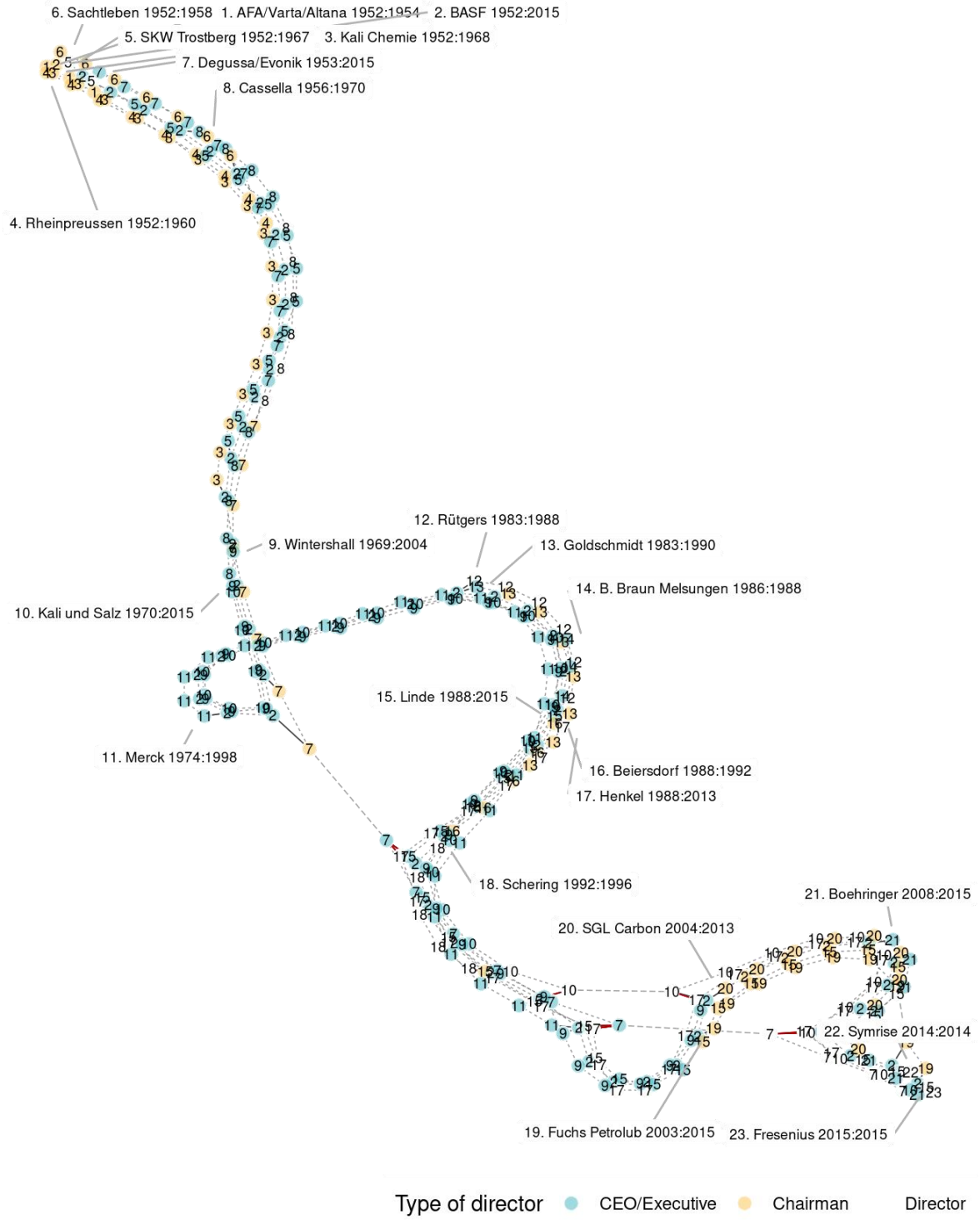


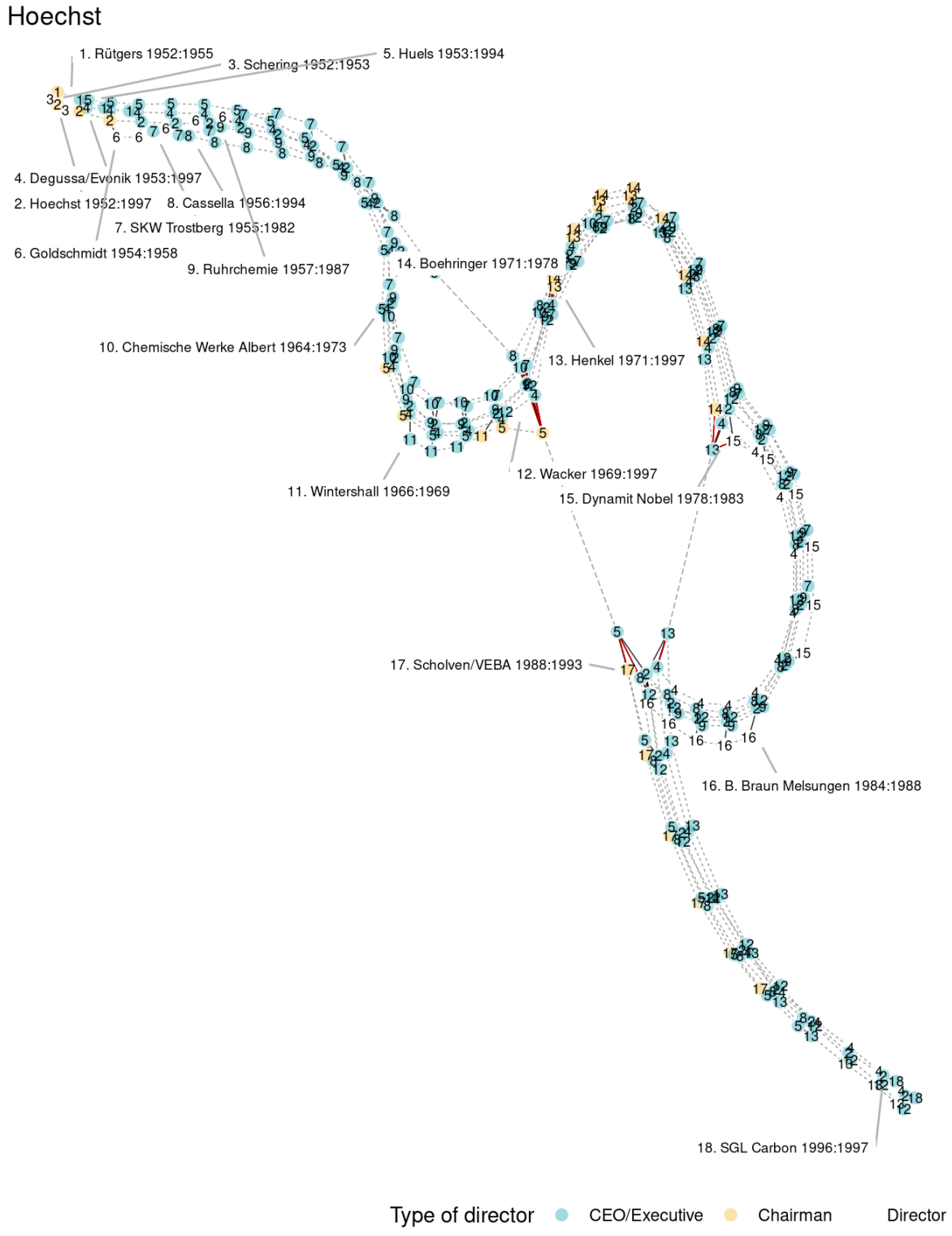
Appendix 2: Evolution of selected company ego networks

Bayer



BASF


6. Sachtleben 1952:1958
1. AFA/Varta/Altana 1952:1954
2. BASF 1952:2015
5. SKW Trostberg 1952:1967
3. Kali Chemie 1952:1968
7. Degussa/Evonik 1953:2015
8. Cassella 1956:1970
4. Rheinpreussen 1952:1960
12. Rütgers 1983:1988
9. Wintershall 1969:2004
13. Goldschmidt 1983:1990
14. B. Braun Melsungen 1986:1988
10. Kali und Salz 1970:2015
15. Linde 1988:2015
11. Merck 1974:1998
16. Beiersdorf 1988:1992
17. Henkel 1988:2013
18. Schering 1992:1996
21. Boehringer 2008:2015
20. SGL Carbon 2004:2013
22. Symrise 2014:2014
19. Fuchs Petrolub 2003:2015
23. Fresenius 2015:2015
Type of director
CEO/Executive
Chairman
Director


Hoechst
1. Rütgers 1952:1955
3. Schering 1952:1953
5. Huels 1953:1994
4. Degussa/Evonik 1953:1997
2. Hoechst 1952:1997
8. Cassella 1956:1994
7. SKW Trostberg 1955:1982
6. Goldschmidt 1954:1958
9. Ruhrchemie 1957:1987
14. Boehringer 1971:1978
10. Chemische Werke Albert 1964:1973
13. Henkel 1971:1997
11. Wintershall 1966:1969
12. Wacker 1969:1997
15. Dynamit Nobel 1978:1983
17. Scholven/VEBA 1988:1993
16. B. Braun Melsungen 1984:1988
18. SGL Carbon 1996:1997
Type of director
CEO/Executive
Chairman
Director

Cassella

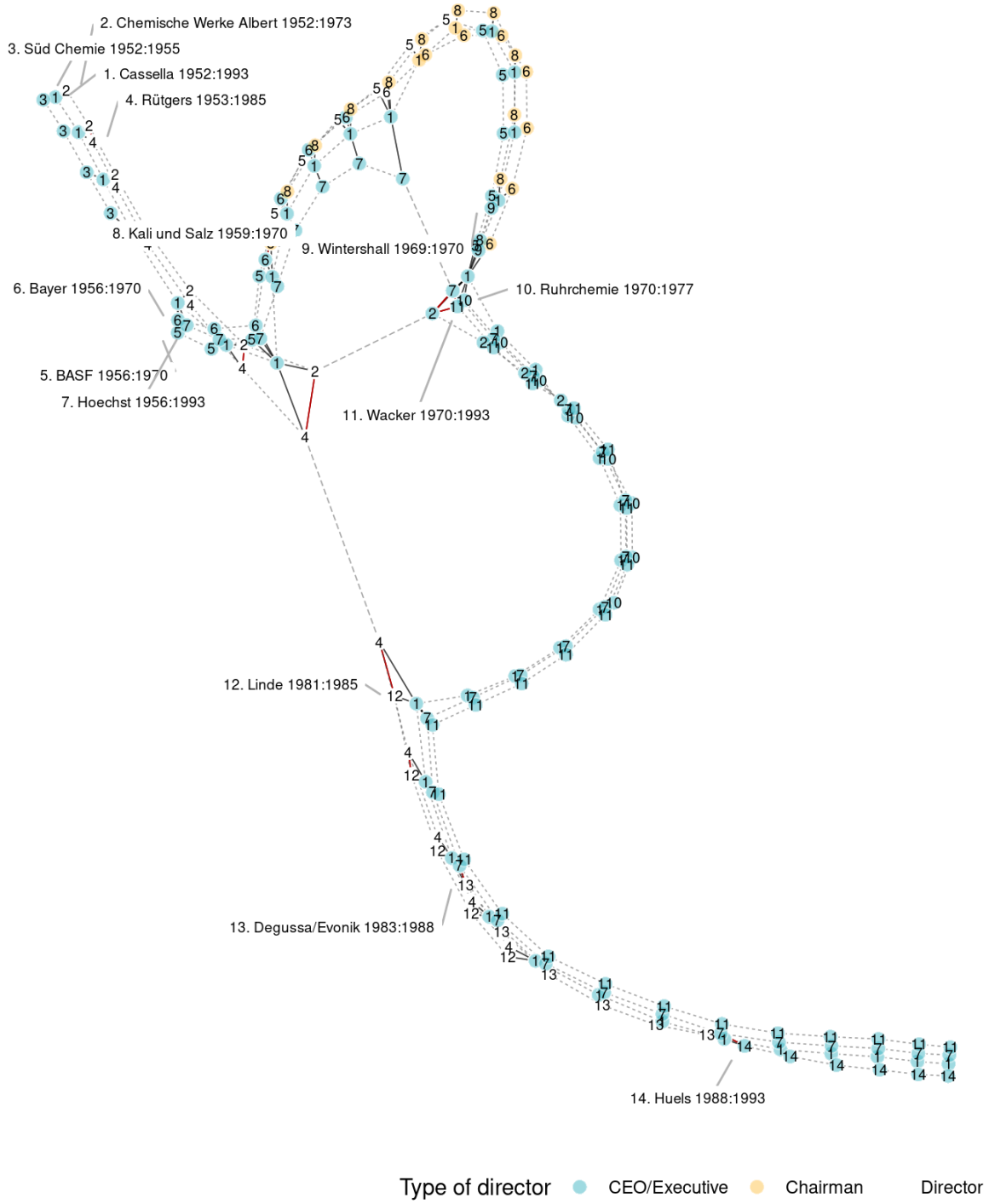

2. Chemische Werke Albert 1952:1973
3. Süd Chemie 1952:1955
1. Cassella 1952:1993
4. Rütgers 1953:1985
8. Kali und Salz 1959:1970
9. Wintershall 1969:1970
6. Bayer 1956:1970
10. Ruhrchemie 1970:1977
5. BASF 1956:1970
7. Hoechst 1956:1993
11. Wacker 1970:1993
12. Linde 1981:1985
13. Degussa/Evonik 1983:1988
14. Huels 1988:1993
Type of director
CEO/Executive
Chairman
Director

Table 1: overview of included companies

	Years recorded	**1953 position**	**1988 position***	**2009-2014 position**
AFA/Varta/Altana**	1950-2015	-	22	16
B. Braun Melsungen	1971-2015	-	-	11
BASF	1952-2015	2	3	1
Bayer	1952-2015	1	1	2
Beiersdorf	1950-2015	19	11	10
Boehringer	1971-2015	-	15	6
Cassella	1952-1994	14	-	-
Chemische Werke Albert	1950-1973	20	-	-
Degussa/Evonik**	1951-2015	6	7	7
Dynamit Nobel	1954-1997	7	20	-
Fresenius	1982-2015	-	25	3
Fuchs Petrolub	1985-2015	-	-	17
Goldschmidt	1950-2002	-	21	-
Henkel	1950-2015	-	4	5
Hoechst	1952-1998	3	2	-
Huels	1953-1998	-	5	-
Kali Chemie	1950-1990	9	-	-
Kali und Salz	1950-2015	11	-	13
Lanxess	2004-2015	-	-	9
Linde	1950-2015	-	19	4
Merck	1953-2015	17	10	8
Rheinpreussen Bergbau Chemie	1951-1966	5	-	-
Ruhrchemie	1950-1988	10	-	-
Rütgerswerke	1950-2003	16	9	-
Sachtleben	1950-1971	18	-	-
Schering	1950-2006	13	6	-
Scholven/VEBA**	1950-1999	8	-	-
SGL Carbon	1996-2015	-	-	19
SKW Trostberg	1950-1999	15	-	-
Stada	1971-2015	-	-	15
Süd Chemie	1950-2010	-	24	-
Symrise	2006-2015	-	-	14
Wacker	1969-2015	-	12	12
Wasag	1953-1999	21	-	-
Wintershall	1950-2004	4	-	
Banks				
Commerzbank	1958-2015	-	-	-
Deutsche Bank	1957-2015	-	-	-
Dresdner Bank	1957-2009	-	-	-

Note. *1953*: The chemical companies featured among the 200 largest industrial enterprises in West Germany, ranked by assets (Chandler, 1990). Burbach-Kaliwerke Salzdetfurth (ranked 11), was not included as the company was taken over by Wintershall in 1955. *1988*: German producers featured on a list comprising the 250 largest chemical companies in the world (Aftalion, 1991). A handful of (mainly smaller) German companies from this list were excluded as they were either holding companies or companies that were not primarily operating in the chemical industry. *2009-14*: The companies listed as the German chemical companies with the largest turnover (Statista, 2015). The two lowest ranked companies on this list, Westfalen AG and DAW SE, were not included as data could not be retrieved.

*Position among German producers.

**The predecessor companies of, respectively, Altana, Evonik and VEBA are included.

References for Table 1 notes (to be added to the references in the main document)

Aftalion, F. (1991). *A History of the International Chemical Industry*. University of Pennsylvania Press.

Chandler, A. D. (1990). *Scale and Scope. The Dynamics of Industrial Capitalism*. Harvard University Press.

Statista. (2015). *Umsatzstärkste deutsche Chemieunternehmen in den Jahren von 2009 bis 2014 (in Millionen Euro)*. https://de.statista.com/

Figure 1: Trends in network cohesion

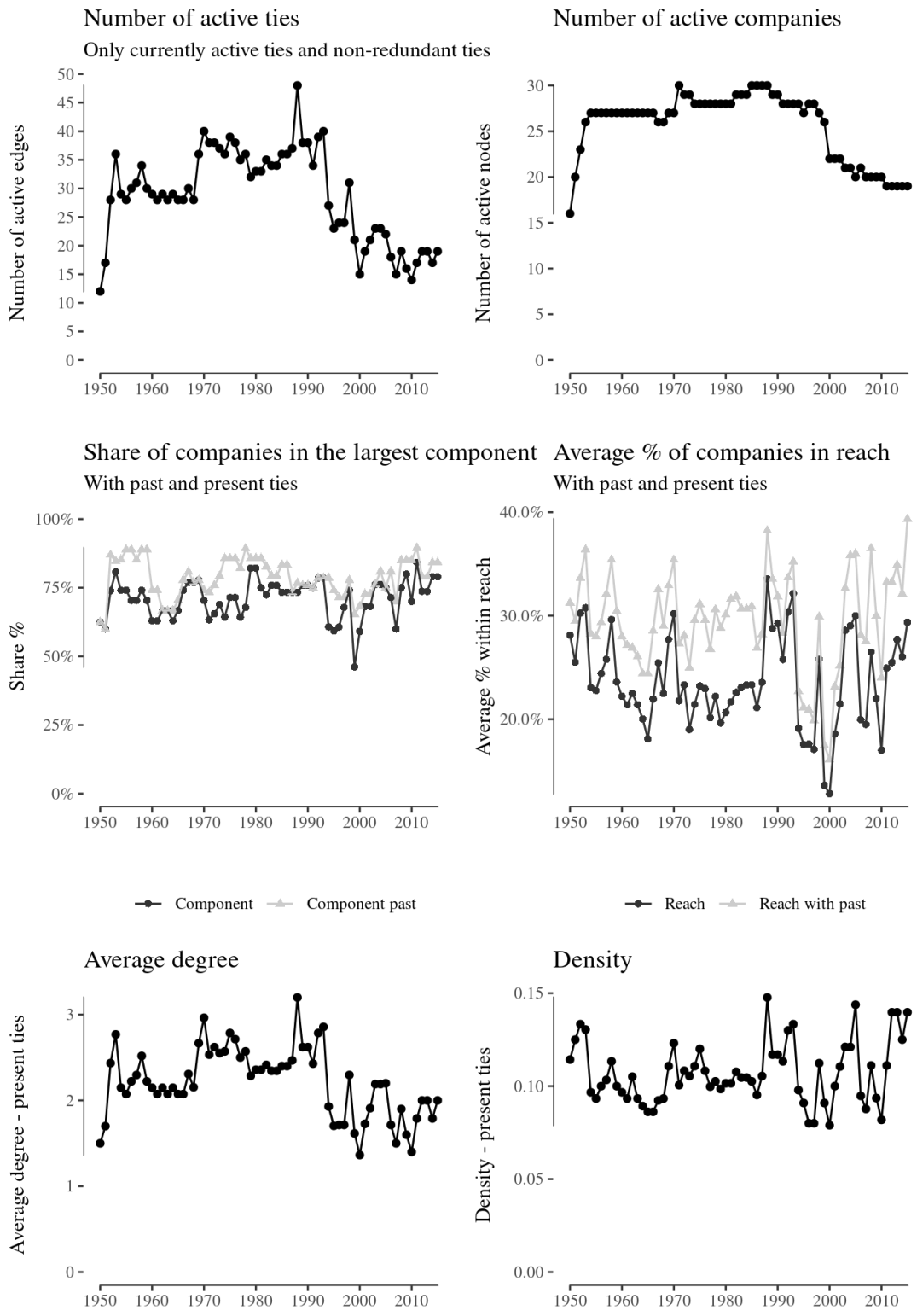
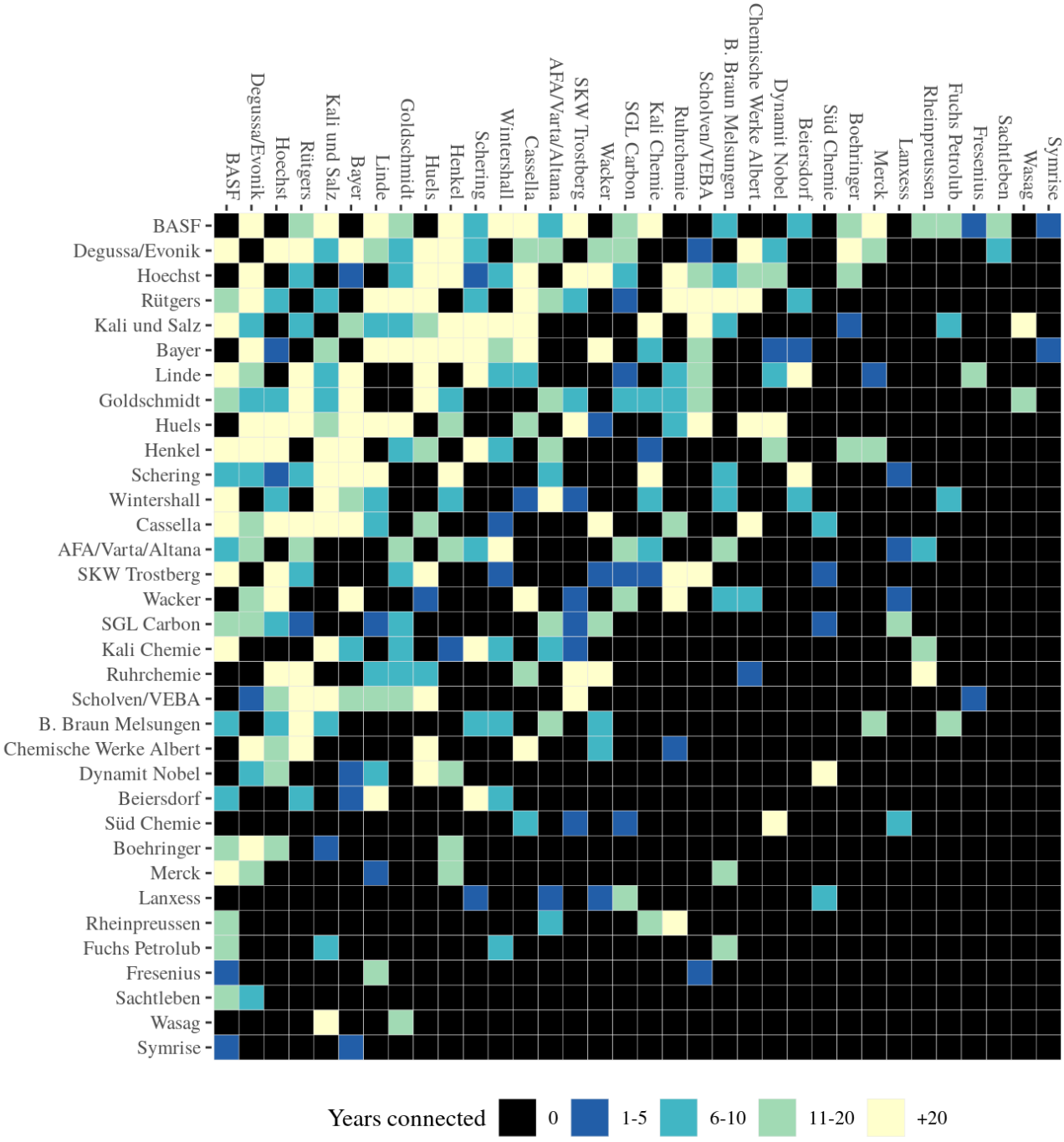


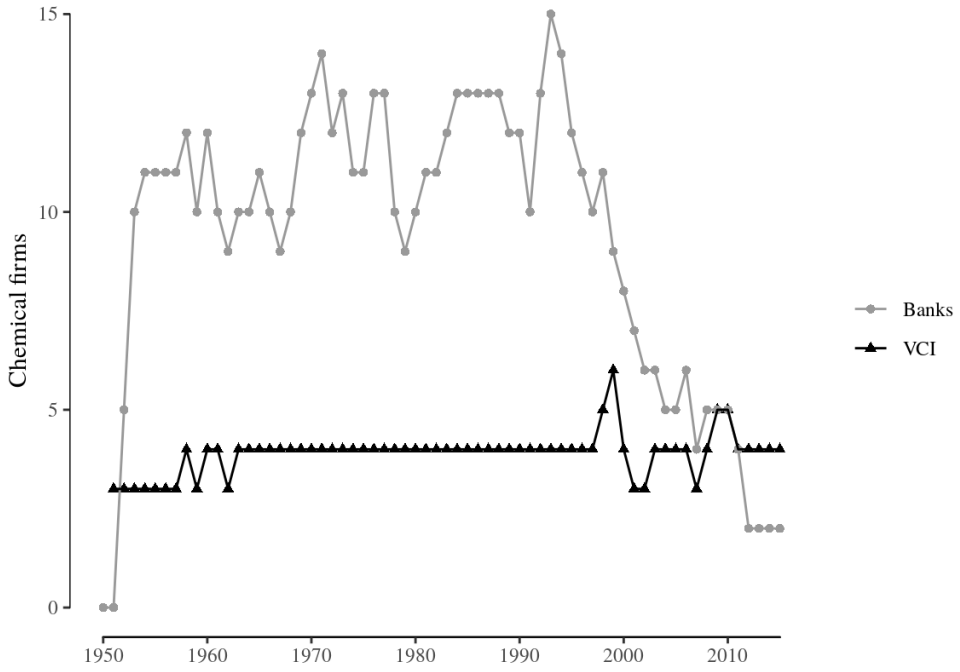
Figure 2: Number of years with direct ties between companies



Note: Sorted by the number of direct connections to distinct companies in the entire period.

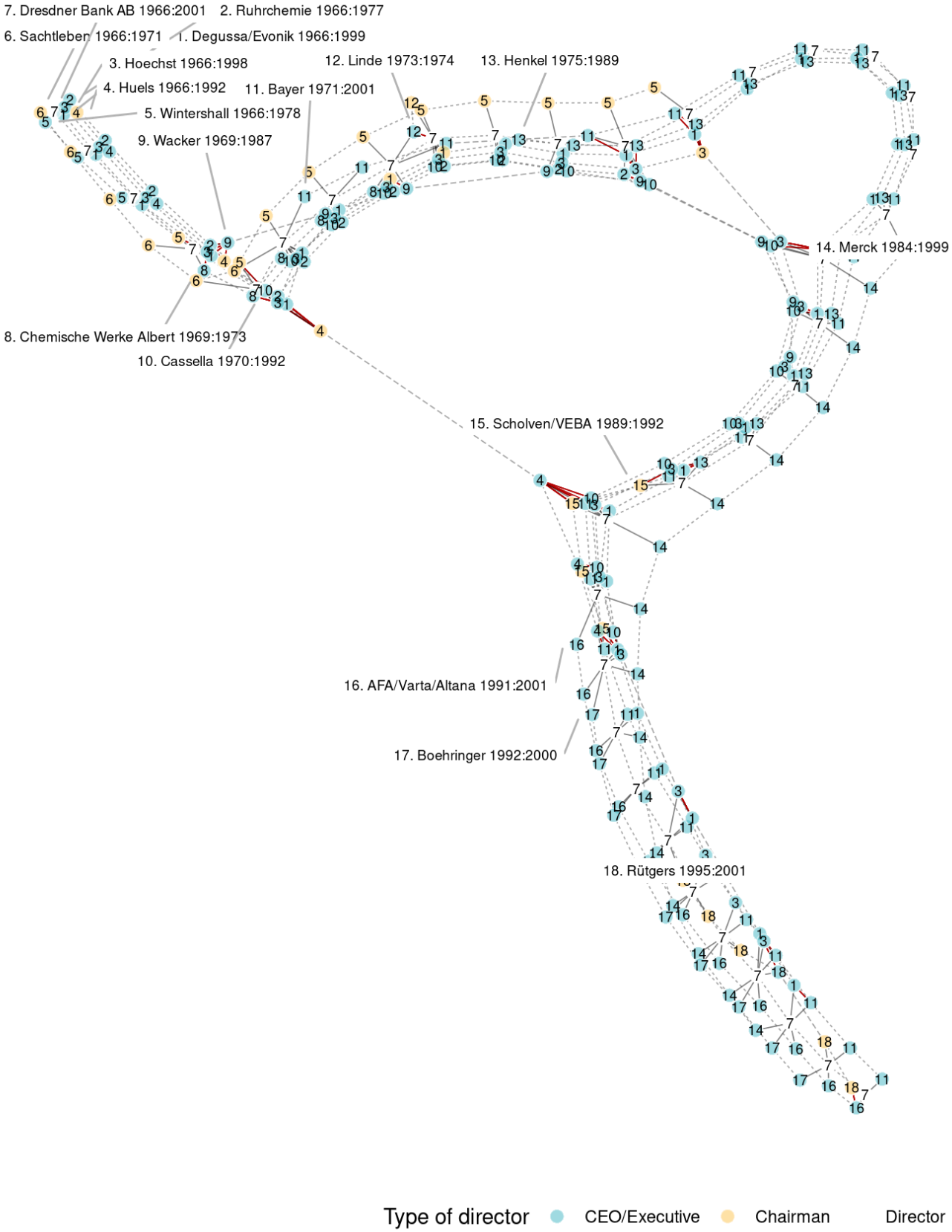
Figure 3: Types of ties and their importance for cohesion

Figure 4: Number of chemical companies on major bank boards or in VCI vorstand



Note: Only counting members of management or chair of the supervisory boards. Bank boards include the supervisory and advisory boards.

Figure 5: Evolution of Dresdner Bank advisory board ego network



Note: The plot shows the year when a chemical company entered and re-entered the ego network - with the first ego network in the top left corner. Dashed lines indicate continued presence, black lines indicate the tie to ego and red lines indicate other active ties between the firms. The shape of the succession of ego networks bends when a tie re-emerges. The colour of the node represents whether the director in question is a CEO/executive director, chairman or managing director in one of the involved chemical companies.