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Fennema, M.; Heemskerk, E.M.

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When theory meets methods: the naissance of computer assisted corporate interlock research

MEINDERT FENNEMA AND EELKE M. HEEMSKERK

*Department of Political Science/CORPNET, University of Amsterdam,
PO BOX 15578, 1001 NB Amsterdam, The Netherlands
(corresponding author) m.fennema@uva.nl*

Abstract *In this article, we study the emergence of computer aided network analysis as an example of ‘Mertonian’ multiple discovery. Computer assisted quantitative network analysis emerged around 1970 and small groups of researchers in different universities, who were independent of each other and looking for the right concepts and computer programs to implement graph theory in social analysis, first applied it to corporate interlock networks. We show how mathematical graph theory provided a toolbox for systematic network analysis and that simultaneously in the Netherlands and the United States this toolbox found an application in the study of corporate power. A historical narrative covers the three main centres in which large-scale corporate network analysis emerged – Amsterdam, California and Stony Brook. For each centre, we provide a sketch of the people involved, the tools they used, and the motivations that brought them to this topic. Our analysis makes clear that one cannot understand the emergence of computer aided network analysis without considering the personal and often political motivations of those who engaged in the first board interlock studies. Insurgent students of political science and sociology pushed for a research agenda on corporate power and found support from scholars who were keen to develop innovative network analysis methods. Hence, corporate network analysis became a legitimate field of research.*

Keywords HISTORY OF SCIENCE, INTERLOCKING DIRECTORATES, NETWORK ANALYSIS, SCIENTIFIC DISCOVERY

Against the ‘heroic theory’ of invention and discovery stands the concept of multiple discovery. The heroic theory allures to the popular idea of the single genius, working in isolation. Multiple discovery, however, builds on the observation that the history of science records thousands of instances of similar discovery by scholars working independently of one another, including the discovery of oxygen, the theory of evolution, or the discovery of the blast furnace, crossbow and magnetism. Scholars, even for

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instance two or three Nobel laureates, are in effect increasingly acknowledging multiple discovery. Reflecting on these observations, Robert Merton (1963: 237) argued that ‘discoveries become virtually inevitable when prerequisite kinds of knowledge and tools accumulate in man’s cultural store and when the attention of an appreciable number of investigators becomes focused on a problem, by emerging social needs, by developments internal to the science, or by both.’ It is the coming together of knowledge, tools and attention that generates innovation and discovery, and seen from this perspective it is not so strange to see how this coming together can take place simultaneously in different spaces.

The emergence of computer assisted quantitative corporate network analysis in the early 1970s is an excellent example of Merton’s view on discovery. Corporate board interlocks, where two firms share one or more directors, have received meticulous attention from scholars since the early twentieth century (Fennema and Schijf 1979). On both sides of the Atlantic, the widespread practice among big business of sharing board members led to grave concerns. Throughout the twentieth century, board interlocking activities remained politically sensitive and a considerable number of studies monitored the extent to which firms and their directors engaged in these networks that, in the words of Supreme Court Justice Louis Brandeis, ‘offend laws, both human and divine’. With hindsight, many of these early studies are remarkable in their empirical sophistication. As early as 1939, Gardiner Means, renowned for his work with Adolf Berle on the separation of ownership and control (Berle and Means 1932), published a report on the structure of the American economy with astonishing matrix inspired visualizations of the network of interlocking directorates among the largest 250 firms in the USA (National Resources Committee 1939). It took at least 40 years to match the sophisticated tables and figures in this report. Board interlock research served as an inspiration for cutting edge methodologies throughout the twentieth century.

However, it was not until the early 1970s that we witnessed a coming together of problems, social needs and developments internal to science that pushed the field of interlocking directorates research into a new stage. The ingredients of this fruitful mix were as follows. First, in the late 1960s, advancements in mathematical graph theory generated for the first time a conceptual toolbox for a systematic analysis of networks. Second, computational facilities became available that allowed researchers to increase their scope of research by several orders of magnitude. And third, the social and political movements of the 1960s triggered an increased interest in corporate elites. These three ingredients came together in the field of corporate interlock research that emerged simultaneously on both sides of the Atlantic.

In what follows, we present a historical narrative of the birth of the field of computer assisted corporate interlock research as an example of multiple discovery in which theory and innovative methods blend with a strong moral or political motive to study corporate power. Our purpose is threefold. First, we want to understand better the drivers that underlie this period of rapid innovation in social network analysis. Second, and related to the first, we want to highlight the importance of personal motivations in such scientific innovation. We therefore build on numerous personal recollections of those involved. In part, it is a personal account as well, for one of us (Fennema) was a

member of the group of scholars in this new field. And third, we reflect on a puzzling observation: while many European researchers mostly abandoned the field of corporate network analysis, along with their radical political views in the 1980s, in the USA the business schools provided a sanctuary for many corporate interlock scholars.

We focus on the emergence of computer assisted quantitative corporate interlock research. Our ambitions are therefore more modest in scope than, for instance, the excellent study by Linton Freeman (2004) on the development of the broader and older field of social network analysis. In the next section, we introduce the three main centres where large scale corporate network analysis emerged – Amsterdam, California and Stony Brook.¹ For each centre, we provide a sketch of the people involved, the tools they used, and the incentives that brought them to this topic. We follow this with a more elaborate discussion of the political motives of some of the early interlock researchers and how these not only contributed to the emergence of this new field of enquiry, but also later led to problems of legitimacy. In the last two sections, we sketch the decline of board interlock research in Europe, and the movement away from sociology to business schools in the USA in the 1980s and early 1990s.

The multiple ‘discovery’ of large scale corporate network analysis

The Amsterdam School

In July 1968, a Dutch trade union leader (Jan Mertens) stated that the real power in the Netherlands was in the hands of 200 business leaders. This revelation shifted the focus to patterns of connections between directors of corporations and public institutions, and the resultant public upheaval this created persisted (Fennema 1976). It was an issue that caught the attention of Robert J. Mokken. After graduating from the Dutch Naval Academy, Mokken studied political science, mass communications and mathematical statistics at the University of Amsterdam. He also taught a course on research methods and had a part-time job at the Mathematical Centre, where he worked with Jacq Anthonisse on statistical software. There, he studied graph theory and reviewed a path breaking book by Harary et al. (1965) on *Structural models* (Mokken 1969).

By the end of 1968, Rob Mokken and Frans Stokman (his former student, close associate and later colleague) were preparing a joint research project for their students. The public ado in the media around ‘Mertens’s 200’ offered a novel subject, methodologically as well as substantively, because one could analyse these interlocking directorates as networks with graph theoretic concepts. The application of these concepts to such large-scale data was new, for social network analysis was still confined to small groups. Moreover, in sociology, the concept of social networks was mainly restricted to personal networks. Mokken and Stokman thought that it was preferable to study the corporate interlock data as structures of power and influence rather than at the level of individuals (cf. the metaphorical ‘old boys network’), as networks between institutions – the financial and industrial corporations.

Since computer programs based on graph theory did not yet exist, Mokken asked Jacq Anthonisse to develop software to analyse large networks (in ALGOL). Mokken and Stokman used this software from 1970 onwards to search for the most central firms

and the directors who carried the networks of interlocks among them. A provisional publication in 1971 created havoc in the Dutch media. A left-wing weekly opened with the headline ‘POWER IS WITH THE BANKS NOT IN PARLIAMENT’ (Mokken and Stokman 1971). That was not a very accurate summary of the results of Mokken and Stokman’s study, which showed that banks had a very central position in the network of interlocking directorates and suggested that they controlled the Dutch economy. In the public debate that followed, they were branded radicals and mainstream economists tried to downplay the importance of interlocking directorates.² As Frans Stokman remembers (Freeman 2004: 117):

An incredible amount of publicity came over us with a broad coverage by newspapers, radio and TV. However, completely opposed to our intention and our main message, the journalists emphasized the list of names of big linkers. We were invited for interviews and discussions. ... Several groups demanded a nationwide discussion. This resulted in a conference on January 19th, 1972 in the meeting room of the Lower House of Parliament.

The group around Mokken published its full results in 1975 under the title *Graven naar macht* (Helmers et al. 1975).³ Economic and historical studies were scarce in the list of references: political science studies predominated. They based their theoretical framework on an elaboration of the concepts of power and influence, in which they associated power with the position of inside directors and influence with outside directors. Strikingly, they found that the 86 largest Dutch firms were connected at the corporate board level through 195 interlocking directors, confirming the popular notion of a power elite. Their most impressive findings were the high and increasing density of the corporate network and the central position of the large banks in the system. A further analysis of the 17 most central corporations showed that these formed a highly connected group with a density of 76 per cent. The remaining 67 non-isolated firms had a density of 11 per cent. In a reanalysis of the data, Fennema (1976) discovered a bipolar structure in the highly connected core. He suggested that this core was less unified than the authors had assumed. The *Graven naar macht* study also included a paragraph on the stability of the lines, which foreshadowed the discussion on broken ties (see below).

The focus on bank centrality in the networks of corporate interlocks stimulated the search for different centrality measures such as degree (the number of adjacent firms) and mean distance (the mean of all distances to other firms in the component). When we add edge information, based on the position of the persons (inside or outside directors), we can include directionality (an executive of firm A who sits as an outside director on board B creates a directed link from A to B). Taking the network perspective one step further, the Amsterdam group became interested in measuring the extent to which a node was central to all other nodes in the network. For this, Anthonisse developed the concept of rush, which is the number of times a firm lies on the shortest path between two other firms in the component (Anthonisse 1971; see also discussion in Newman and Girvan 2004). A couple of years later, Linton Freeman (1977) developed a similar notion under the name of ‘betweenness centrality’. The computer programs that the Amsterdam

research group used were eventually called GRADAP, but an earlier version was called Graphlib (Anthonisse and Lageweg 1975; Sprenger and Stokman 1982). The rush measure was implemented in GRADAP, but not in any of the next generation packages.

In 1972, inspired by the work of Mokken and Stokman, a group of students in the Department of International Relations, headed by Meindert Fennema, started to collect data on interlocks among the 176 largest private firms in North America, Europe and Japan. They found an integrated transatlantic network in which Dutch and British firms formed bridges between Continental European, US and Canadian clusters. The highest national densities were in Germany, Switzerland, the Netherlands and Sweden, and the lowest in Great Britain, Japan and the USA. Banks were the central nodes, both in national and transnational networks, but the Japanese component was separate from the Atlantic one. It took ten years to publish the full results, but some findings (Fennema 1982; Fennema and De Jong 1978; Fennema and Kleyn 1979) were available earlier.

During the 1970s, the Amsterdam group was a thriving community of Marxist scholars and power structure theorists who worked together closely and had a strong international orientation, but this did not last. By the end of the decade, the Amsterdam group had fallen apart. In 1977, Frans Stokman left Amsterdam to take a chair at the University of Groningen; Rob Mokken had accepted a position on the board of directors of the Netherlands Bureau of Statistics, but continued to supervise Ph.D. dissertations part time, including those of former group members Schijf (see Schijf 1993), Fennema (1982) and Zijlstra (1979). Some members of the former Amsterdam group continued to work on corporate interlocks, but they drifted apart.

The Stony Brook School

Around 1970, the application of graph theory attracted the attention of social scientists in the USA⁴ and here we see the same mixture of political engagement and theoretical and methodological advancements. Michael Schwartz, a student activist engaged in Students for a Democratic Society, was to become a hub in the network of scholars who started to do research on networks of corporate interlocks. As he remembers:

The animating moment was a Spring 1969 strike by insurance workers against John Hancock Insurance ... in Boston. In order to convince them (and ourselves) that they were fighting a common enemy, a couple of us began looking up connections between Hancock and the main military contractors providing weapons for the war (for example, General Electric and Dow chemical). We combined a nice list and wrote up leaflets that we distributed to the workers and to other folks to gain support for the strike and used it for our anti-war activities.⁵

Schwartz received his doctorate from Harvard, where he was a student of Charles Tilly and Harrison White, one of the founding fathers of social network theory. He began working systematically on corporate board interlocks in 1970 when he read a prepublication copy of an article by Philip Bonacich on network centrality. They had been graduate students and friends at Harvard under Harrison White. In 1967, Bonacich

moved to UCLA and in 1969 Schwartz joined him there. So, as the Amsterdam group started to work on networks of corporate interlocks, Michael Schwartz and Philip Bonacich started to study corporate networks in Los Angeles. Bonacich published his first articles on network analysis in 1972 (Bonacich 1972a; 1972b). When UCLA expelled Schwartz in 1970, after a sit in, he moved to Stony Brook where many talented Ph.D. students soon surrounded him.⁶ His research on interlocks was theoretically inspired by Lenin's (1916) seminal essay 'Imperialism, the highest stage of capitalism', which in turn leaned heavily on Rudolf Hilferding's (1910) *Das Finanzkapital*, translated into English in 1981 (Hilferding 1981).

The circle around Michael Schwartz consisted of William Atwood, James Bearden, Peter Freitag, Carol Hendricks, Peter Mariolis and Beth Mintz. Of this group, it was Peter Mariolis who collected a large dataset of corporate interlocks based on the top 800 US corporations. This dataset was the basis of the group's work on bank centrality first presented in 1975 at the Annual Meeting of the American Sociological Association (Bearden et al. 1975). The same year, Peter Mariolis (1975) published a single authored paper on interlocking directorates and the control of corporations.

Just as the Amsterdam group developed the concept of rush, the Stony Brook group used centrality measures that tried to go beyond counting direct ties. They resorted to the concept of peak centrality developed by Philip Bonacich. This centrality measure depends on the number of firms with which a given firm interlocks; the intensity of these interlocks; and the centrality of the firms with which a given firm interlocks (eigenvector centrality). However, the contribution of these more complex measures was immediately disputed. Peter Mariolis found in his 1975 article that the correlation between this multiple centrality index of Bonacich and the simple degree centrality was 0.91. Linton Freeman summarized the different concepts of centrality in an article in the first volume of the journal *Social Networks* (Freeman 1979).

Carol Hendricks and Beth Mintz were the only women in this emerging network of critical researchers of the corporate elite, which was, like the corporate elite itself, a man's world. A second generation of Ph.D. students soon followed the early group at Stony Brooks – Mark Mizruchi, Don Palmer and Davita Glasberg. Mark Mizruchi chose to go historical and to study networks of corporate interlocks from 1904 to 1974. He found that during the whole of the twentieth century financial institutions had been the most central firms in the network. He also showed that, due to the Clayton Act in 1914, the number of interlocks between financial institutions declined from 124 in 1912 to 19 in 1919. Legislation indeed had a serious impact on the networks of corporate interlocks. Mizruchi's dataset contained a gap between 1935 and 1964, but the 1964 network was very like that of 1935. Between 1964 and 1969 the density of the corporate network increased again, which was exactly what Mokken and Stokman had found for the Netherlands.

UC at Santa Cruz and Santa Barbara

Another set of early users of computer programs for the analysis of corporate networks were John Sonquist, Thomas Koenig and Robert Gogel. Sonquist, who was a Quaker pacifist, had been working in Ann Arbor and moved in 1970 to the University of

California at Santa Barbara. At the time Koenig was studying at the University of California at Santa Cruz. He had taken classes with William Domhoff as an undergraduate student in psychology.

As a child protective services worker in Oakland, who was majoring in psychology, I liked Domhoff's Millsian emphasis on the social side of the elite and logrolling for mutual benefit. Finance capitalism and other dialectical models were very new to me and often mixed with New Left terminology that I found confusing.⁷

Domhoff (1967) had just published his path breaking study, *Who rules America?* Koenig later became a Ph.D. student of Sonquist.

Sonquist and Koenig used the concept of clique to find cohesive clusters in the largest component of the network of corporate interlocks. Koenig writes: 'The program that John Sonquist and I used was a modification of Richard Alba's technique as described in "A graph-theoretic definition of a sociometric clique"' (Alba 1972, 1973; Alba and Kadushin 1975). At Columbia, Alba was involved in Charles Kadushin's (1974) classic empirical study of the American intellectual elite. Alba was interested in identifying what areas of a network are more densely connected than others. Using the earlier work of Duncan Luce, he introduced the notion of sociometric cliques. Sonquist used his programs in a seminal article he wrote with Thomas Koenig (Sonquist and Koenig 1975), which they published in a special issue of *The Insurgent Sociologist*, which Bill Domhoff edited in 1975. The earlier work of Tom Koenig and John Sonquist was already in circulation in 1973 (Koenig et al. 1973).⁸

Meanwhile, others from the group around Harrison White undertook related work. White's collaborator Ronald Breiger experimented with block modelling to investigate larger social networks (White et al. 1976). At the University of Michigan, White's student Joel H. Levine was working on large networks of interlocking directorates. His 'The sphere of influence' (Levine 1972) was an attempt to represent such networks by using the smallest space analysis based on nonmetric multidimensional scaling. Stephen Berkowitz, another of Harrison White's students, was also an early bird in quantitative network analysis. With three other researchers from the University of Toronto, he (Berkowitz et al. 1979) wrote on enterprise grouping through combined ownership and directorship ties. They did not use network programs based on graph theory, but Berkowitz did attend the Conference on Mathematical Approaches to the Study of Social Power at the Werner Reimers Stiftung in Bad Homburg, which Frans Stokman and Rolf Ziegler hosted.

Bridging the Atlantic

The study by the Stony Brook group had a strong affinity with the one that Robert Mokken and Frans Stokman had set up in Amsterdam. Both groups focused on bank centrality and on the power structure of the corporate elite. Both focused more on firms than on directors. Both also had a special interest in structural relations between

business and government (Freitag 1975; Mintz 1975; Mokken and Stokman 1979). While Sonquist and Koenig were building on Alba's concept of sociometric cliques, in his seminal paper on 'cliques, clubs and clans', Rob Mokken (1979) was extending the work on those cliques. The three groups clearly had similar interests, but did not yet work together. It was the newly formed European Consortium for Political Research (ECPR) that created a platform for international collaboration; in Strasbourg in 1974, one of its joint sessions of workshops was on the internationalization of capital. There, Fennema presented a paper on the European automobile industry using network analysis⁹ and at the 1976 ECPR conference at Louvain, he and De Jong presented their first results on the international networks of interlocking directorates. The first personal encounter between the Amsterdam and Stony Brook groups took place in 1978 when Beth Mintz attended a planning session at the ECPR joint sessions of workshops in Grenoble, dedicated to a comparative analysis of nine European countries and the USA. She became the bridge between the Amsterdam and Stony Brook groups.

John Scott also attended that planning session, as did Rolf Ziegler. Scott had started his career at the University of Strathclyde and became involved in research on the ownership and control of Scottish industry. Scott was a member of the British Sociological Association's Quantitative Sociology Group and there developed an interest in network analysis through contacts with Barry Wellman, Joel Levine, Michael Schwartz and Frans Stokman. He was to become the principal proponent of network analysis in Britain (Scott 1978, 2002). Rolf Ziegler, from Munich University, became an important organizer in a ten-country study of corporate networks, which we discuss below. Ludo Cuyvers and Wim Meeusen of the University of Antwerp also attended the Grenoble workshop. The ECPR organized new workshops in Brussels in 1979, where Antonio Chiesi of the University of Milan joined the group, and in Florence in 1980.

Mokken and Stokman were also *ab initio* involved in the foundation of the International Network of Social Network Analysis (INSNA) by the Canadian scholar Barry Wellman in 1977. Before the INSNA started to organize the annual SUNBELT conferences that took place for the first time in 1981 in Tampa, they founded the journal *Social Networks*. Linton Freeman from Lehigh University was its editor, J. Clyde Mitchell from Oxford University and Rolf Ziegler its co-editors, and Philip J. Stone and Ronald L. Breiger (both from Harvard) its computer program editors. Scholars from the USA, Canada, Germany, France, Norway, Denmark, Israel and the Netherlands were among those on its editorial board. The entire fourth issue of *Social Networks* was dedicated to research on corporate interlocks, and a fair share of the articles came from the Grenoble workshop, including Gerrit Jan Zijlstra's (1979) one on nuclear energy policy in the Netherlands and the paper presented by Mokken and Stokman (1979). Dutch authors from the Amsterdam group wrote three of the five papers, and a group of Canadian authors led by Stephen Berkowitz (Berkowitz et al. 1979) wrote another. Fennema and Schijf (1979) presented an overview of the international literature on interlocking directorates. They discussed the early studies of corporate interlocks in Germany, the Netherlands, the United States, Great Britain, France, Sweden, Switzerland, Spain and Belgium. However, they missed a recently published study on interlocks between Canadian and US firms by Clement (1977).

The first volume of *Social Networks* contained five articles by scholars from outside the USA, but the issue on corporate interlocks contained four of these. Ronald Burt, a young scholar who had just received his Ph.D. from the University of Chicago, wrote the fifth paper in the special issue on corporate networks, titled 'A structural theory of interlocking corporate directorates' (Burt 1979).

Politics and critical theory as inspiration for interlocking directorates research

The group of interlocking directorate researchers had their fair share of critical scholars on both sides of the Atlantic. In the USA, this manifested itself as part of the broader rebellion in the field of industrial organization studies directed against the managerial control thesis that Berle and Means espoused in 1932 and that after the Second World War became conventional wisdom. According to Berle and Means (1932), the owners of large firms lost control through the dispersion of shares, thus allowing the managers to take over their firms. Marxist authors like Sam Aaronovitch (1961), Victor Perlo (1957), Anna Rochester (1936) and Paul Sweezy (1953) had challenged this managerial control thesis, but now a new generation of critical scholars attacked it by confronting it with new data (Lerner 1966; Palmer 1972; Zeitlin 1974).¹⁰

A reanalysis of the data suggests that Berle and Means had indeed exaggerated the extent of management control. Burch (1972) estimated that in 1929 between 37 and 45 per cent of top non-financial companies were family controlled and that Berle and Means had classified many of these as 'managerial controlled'.¹¹ The insurgent sociologists, however, wanted to go further. They were interested in power relations in the economic system at large and in power holder influence over the political elite. The Stony Brook group delivered the aforementioned Bearden et al. (1975) paper with the programmatic title of 'The nature and extent of bank centrality in corporate networks'. This marked the start of a long research track that led to Mintz and Schwartz's (1985) impressive book, *The power structure of American business*. A major innovation in the work of Bearden et al. (1975) was the distinction between primary and secondary interlocks, which they called strong and weak ties. The latter refer to interlocks induced between company B and C because of an interlock between A and B and A and C that an inside director of A carries. They saw such weak or secondary interlocks as unintended consequences of the decisions that company A and B and company A and C take. According to Granovetter's (1973) seminal paper, it was misleading to call such ties weak. Drawing mainly on small group research, Granovetter distinguished between strong friendship ties and weak acquaintance ties. His main argument is that strong ties are more likely to form a circle of friends with a high degree of mutual choice and little diffusion of information and ideas outside the group. Weak ties, though, form local bridges between otherwise separated individuals and groups, but the way Bearden et al. defined weak ties did not correspond with the definition of Granovetter's weak ties.

In Amsterdam, Mokken and Stokman did not work from a Marxist perspective, but one of us (I, Fennema), as a Ph.D. student of Rob Mokken, was at the time a Marxist. I delved into the literature of finance capital that had emerged in Germany and the Netherland between 1900 and 1920. A German banker, Otto Jeidels, had done most of

the initial empirical work, while an Austrian, Rudolf Hilferding, who later became minister of finance in Berlin, had done most of the early theoretical work (Jeidels 1905; Hilferding 1910). Both authors agreed that bankers play a crucial role in the organization of industry and society. Hilferding argued that the dense networks between banks, industry and the state was an expression of a developing state capitalist trust that tendentially eliminated all forms of competition within a country and elevated capitalist competition to the international level where economic competition between countries would eventually lead to economic and military warfare. Hilferding's analysis forecasted the First World War and became very influential in Germany. A study by J. Riesser (1910) showed that trade unions had become part of the state capitalist trust system. In the Netherlands, Floor Wibaut (1913) investigated the spheres of influence of the seven largest banks.

Vladimir I. Lenin's (1916) essay on 'Imperialism, the highest stage of capitalism', was, however, what gave Hilferding and Riesser's theory a world forum. Lenin had also based this essay on the work of Nikolai Bukharin (1915) who wrote *Imperialism: a study* (see Fennema 1982 for an evaluation of the early theories of imperialism) and who, in turn, the British economist John Hobson (1902) had influenced. In his revised version of *The evolution of modern capitalism*, Hobson (1906) included a section on corporate power and interlocking directorates. His inspiration came from the early overview of interlocking directorates that Balthasar H. Meyer had included in response to a paper on trust presented at the sixteenth annual meeting of the American Economic Association in 1903 (Meyer et al. 1904: 111). Hobson (1906: 270) later included a similar tabulation of interlocking directorates between South African gold and diamond producers, as well as perhaps the first sociogram in corporate power research.

Lenin slightly amended Hilferding's theory by stating that the merger between banks, industrial firms and the state was incomplete and that monopoly capital could also work through foreign states, especially in the less developed economies. In turn, he correctly argued that many of the trusts and cartels were of an international nature. Lenin's theoretical model was less clear-cut than Hilferding's, which made it rather resistant to any form of falsification (Fennema 1982). At the outset of the First World War, the German Marxist Karl Kautsky (1914) launched the counter intuitive thesis that international cartels and trusts would eventually bring capitalist world peace. Fennema's research on transnational networks seemed to support Kautsky's theory, at least for the Atlantic world. The Japanese network seemed more organized, at least according to the Hilferding model of a state capitalist trust. In 1970, there was an Atlantic component of interlocking directorates that had national clusters connected by international interlocks. By 1976, this network had become much more transnational: the number of international interlocks in the Atlantic component had increased by 50 per cent and now also had two (advisory) links with the Japanese component. International bank consortia had been formed and seemingly organized according the principle, 'the enemies of my enemy are my friends (Fennema 1982: 164). Hence, national competition among banks played out in the international arena.

Lenin, of course, was well known in the USA, but for obvious reasons academic scholars were hesitant to cite him. Even people like Michael Schwartz and Beth Mintz,

who had an affinity with Marxism, had to be careful not to advocate their political convictions openly. Bearden et al. never cited Lenin, but they did cite the work of two US scholars, Anna Rochester (1936) and Victor Perlo (1957), who upheld the Leninist tradition and used a communist publisher. Both were staunch followers of Hilferding and Lenin, as the titles of their empirical studies – Rochester’s *Rulers of America* and Perlo’s *The empire of high finance* – suggest. Bearden et al. also found inspiration in the anti-trust investigators of the US Congress, which had, of course, a much higher level of legitimacy (National Resources Committee 1939; US Congress 1965, 1967, 1968; US Federal Trade Commission 1951). The members of the Stony Brook group had read Lenin, but a translation into English of Hilferding’s *Das Finanzkapital* did not happen until 1981 and then only because of a growing interest in the role of the banks in corporate governance. In Europe, of course, language barriers did not exist, neither did the fear of communist contagion.

The fading away of board interlock research in Europe

Following up on the Dutch corporate network study published in 1975, Rolf Ziegler from the University of Munich obtained a grant from the Werner Reimer Foundation to set up – together with Frans Stokman – an international research group to collect data on interlocking directorates in ten countries. The research group organized three sessions in Bad-Homburg. Because the idea was to have comparable datasets for each country, the comparative study required an enormous amount of planning and logistics. The international research group consisted of 25 scholars who met on a regular basis at the late Werner Reimer’s mansion in Bad-Homburg. Three of the members of the former Amsterdam group participated (Stokman, Fennema and Schijf) and two members of the Stony Brook group were involved (Mintz and Bearden). As mentioned, Stokman had moved to the Department of Sociology at the University of Groningen. Under his supervision, Frans Wasseur did the computer analysis with the GRADAP program library, which by then was fully documented (Stokman and van Veen 1981). Participants from Antwerp University (Ludo Cuyvers and Wim Meeusen); from the University of Trieste (Antonio Chiesi); from the University of Helsinki (Illka Heiskanen); the University of Vienna (Gerhard Reissner); the University of Zurich (Peter Rustenholz), Boston University (David Schwartz) and the University of Leicester (John Scott) visited Groningen. John Scott joined the editors in the final stage of the research. Frans Stokman, Rolf Ziegler and John Scott, finalized the manuscript in 1983; the book came out in 1985 (Stokman et al. 1985). Although translated into Japanese, it was relatively little cited for such a major contribution. (According to Google Scholar, in September 2017 the book had only 363 citations, most of which were after 2002 when the study of corporate interlocks picked up again.)

After 1985, Stokman’s research interest moved in the direction of elite recruitment. Van der Knoop, whose dissertation he was supervising, interviewed the big linkers – those holding many supervisory positions in large companies in the Netherlands – and analysed career patterns in corporate networks over time. The two of them, along with Wasseur (Stokman et al. 1988) convincingly showed that corporate networks were

important for the development of shared norms and values among corporate elites. Fennema and Jaap Dronkers likewise studied recruitment patterns among the corporate elite in the Netherlands (Dronkers and Hillige 1995; Hillige and Fennema 1992). Fennema (1989) also applied network analysis to his study of the decolonization of Indonesia. The view that interlock networks were drivers of elite cohesion based on shared norms and values was, more than ten years later, taken up by Bill Carroll and Meindert Fennema in their studies on the global corporate elite, and this reignited the field of board interlock research (Carroll and Fennema 2002; Carroll et al. 2010; Heemskerk et al. 2016a). Later, Stokman and his Ph.D. students at Groningen University developed a model to study the impact of networks on political decision making (Buena de Mesquita and Stokman 1994; Stokman and Van den Bos 1992). They used his two-stage model of political decision making to forecast the outcome of complicated policy decisions.

While many of the early quantitative researchers on European interlocking directorates moved on to other topics and interests, the first generation of computer programs they had developed for network analysis eventually became outdated. GRADAP, for instance, was built for a certain system. Frans Wasseur had to analyse all datasets for the Networks of Corporate Power project in Groningen at the CYBER main frame.¹² Frans Stokman applied for a grant from the Dutch National Science Foundation to make the GRADAP system independent of CYBER, but failed to secure it because the National Science Foundation only supported innovative research. There was also a first-generation German network program, SONIS, which was even more complex and had a command language in German. Other first-generation US network programs were SONET, NEGOPY and STRUCTURE (the latter designed by Ronald Burt) (Freeman 1988).

Of the computer packages for network analysis, UCINET prevailed. Linton Freeman launched it in 1983 and Stephen Borgatti and Martin Everett developed it further in 1992 (Borgatti et al. 2002). The first version was certainly no better than GRADAP in content, but it was compatible with an IBM mainframe, which GRADAP was not. GRADAP had been written in Fortran for a CDC mainframe with a strong emphasis on handling large data matrices. This was what the program intended, for analysing networks of corporate interlocks requires large data matrices. This platform dependence meant that GRADAP could not be taught in workshops at the Sunbelt conferences in the USA, where only IBM mainframes were available. While GRADAP could handle larger datasets, UCINET was easier for unexperienced users. There was an English language manual for GRADAP, but only in 1989.¹³ The Dutch and Germans may have been superior innovators, but the Americans were better at marketing (Borgatti et al. 2002).

How the business schools took over in the USA

The political motivation of some of the early scholars was an important driver behind the popularity and growth of research on interlocking directorates. However, as time progressed, it increasingly became a liability. Compared with Europe, research in the USA on corporate interlocks and bank control was far less inspired by the Marxist notion of finance capital, for Americans did not consider Marxism a legitimate

intellectual tradition. In the USA, anti-trust research had a long and legitimate tradition and it was from this that the concept of resource dependency arose and went on to become the theoretical underpinning of board interlock research. Jeffrey Pfeffer (1972) elaborated, if not invented, resource dependency theory and explained the existence of interlocking directorates as a strategy for decreasing a firm's dependency on outside resources. Such an interpretation again made the firm, rather than its owners or group of elite corporate directors, the unit of analysis. Pfeffer's theory also provided an alternative explanation for the centrality of the bank in the corporate network by focusing on credit relations rather than power relations between banks and industrial firms. Bank centrality would accordingly not be the proof of an evil empire of high finance, but a reciprocal dependency of banks and industrial firms. Hence, the corporate elite would not just be the willing executors of the interests of corporate owners; they would, rather, be the defenders of the corporations' individual interests rather than the collective interests of the capitalist class (Allen 1974, 1978).

Because Pfeffer's and Michael Allen's main empirical interest was in bipartite densities between sectors of industry, this limited the amount of attention they could give to network analysis. Mark Mizruchi, however, continued to study corporate networks from a resource dependency perspective. In the following lengthy quote, he explains why resource dependency theory was so attractive to him:

Schwartz and his students had shown that there were a lot of interlocks, and I had shown that there were a lot of them in the old days and a lot of them in the present. One question began to be raised against this work, however: there may be a lot of interlocks, but so what? What difference does it make? To what extent do these ties affect actual behaviour among firms? To what extent do they demonstrate the existence of a capitalist class that acts collectively in a unified manner? At first, I tried to argue my way around the question, claiming that we were dealing with power, which typically cannot be empirically observed, and therefore there was no reason or need to demonstrate behavioural consequences of interlocks. I even published an article to this effect in the *Academy of Management Review* (1983), in which I argued that even if they are rarely involved in decision making, boards of directors control corporations because they have the power to step in and fire the CEO during times of crisis. That piece was often cited by business scholars working within an agency theory perspective. I doubt that any of them had any idea that I had written the paper to justify my claim that there was a unified capitalist class in the United States. Meanwhile, I had developed a theoretical argument in which I tried to synthesize the social class model of interlocks and the resource dependence model. I liked the resource dependence model for two main reasons. First, its use, especially by Jeff Pfeffer, had helped to legitimize the study of interlocks. Second, I liked its structural implications, the idea that firms might become tied due to structural forces such as interdependence rather than just social ties. This seemed more consistent with Marxism, I thought, and I also thought it provided a good explanation for interlocks, the broken-tie studies notwithstanding.¹⁴

According to Mizruchi, the resource dependency approach provided the power structure researchers with the legitimacy they needed to survive in academia.

Another route American scholars took to emphasize the relevance of board interlocks was to focus on corporate donations to political parties and their effect on federal decisions. While Thomas Koenig (1979) was the first scholar to adopt this line of enquiry, Beth Mintz and Michael Schwartz picked up the issue in the early 1980s and published an influential article on interlocks and interest group formation (Mintz and Schwartz 1981). Later, Mark Mizruchi worked with Tom Koenig on the impact of interlocks on corporate donations to political parties and candidacies (Mizruchi and Koenig 1986). They found none. Later, however, Mizruchi (1992) found that companies engaging in relations with the same financial institutions made similar political contributions. This study provided the first comprehensive evidence that interlock ties had demonstrable effects on corporate political behaviour. Likewise, Val Burris (1987, 1991) initially found no meaningful relationship between interlocks and campaign contributions, but in a later study concluded that interlocks did affect the corporate elite's political behaviour. Clawson and Neustadt (1989), however, found a significant (negative) correlation between the number of interlocks and donations to conservative political action committees. They found a positive relation between the number of interlocks and donations to incumbent members of Congress. These inconclusive results added to the feelings among scholars that interlocking directorates generally did not function as direct channels of influence from firms to politicians.

Because of the debate between resource dependency theorists and power structure scholars a new topic came to the fore that, at least in the short run, presented a significant threat to the relevance of research on interlocking directorates. If the resource dependency theorists were right, argued Thomas Koenig, Robert Gogel and John Songquist (Koenig et al. 1979), one would expect to see interlocking directorates replaced when a director died or retired. However, they found that these 'broken ties' were only replaced in 6 per cent of the cases. Yet, the overall structure of the corporate network remained stable between 1965 and 1969 (Koenig and Gogel 1981). To them, this suggested that they should reject both the resource dependency model and that of direct bank control through interlocking directorates, but instead support the class hegemony model. Don Palmer's (1983) dissertation research confirmed these first findings, which was a blow to resource dependency theory. Johannes Pennings (1980), who firmly grounded his work in organizational theory, initiated the search for a direct causal relationship between corporate interlocks and profitability. He had studied sociology in the Netherlands, at Leiden and Utrecht rather than Amsterdam, and graduated in 1968. He then moved to the University of Michigan to write a Ph.D. on structural interdependence and firm effectiveness under the supervision of Robert Kahn. He failed to find a robust correlation between board interlocks and firm performance and later attempts to establish this connection gave mixed results. The causal relationship implicit in resource dependency theory between corporate interlocks and profits was thus never substantiated (Meeusen and Cuyvers 1985; Richardson 1987; Zahra and Pearce 1989). Resource dependency theory seemed of little use to explain corporate interlocks. Models based on dyadic relations between firms or those

between firms and political institutions had become obsolete. This signalled the end of the first wave of the study of networks of corporate interlocks.

Ronald Burt (1983) then took a new turn by adopting the industrial sector as a unit of analysis and focusing on the tendency of firms to use interlocking directorates to hedge against market uncertainties and resource dependencies. Burt's (1992) big hit, however, was the concept of a 'structural hole' launched a decade later. He argued that filling a structural hole was an essential part of entrepreneurial activity. The idea took off, and the book has nearly 20,000 citations. His notion of structural holes builds on the concepts of *rush* and *betweenness* as developed by the early research groups on board interlocks, and indeed on a fundamental network analytic understanding of organizational dependencies. Burt successfully reformulated the argument of the early board interlock researchers that network position needs to take account not only of a firm's neighbours, but also of its neighbour's neighbours and so on. A year after receiving his Ph.D. in organizational behaviour at Stanford, Jerry Davis (1991) published a highly influential paper in which he argued, and demonstrated empirically, that the network of interlocking directorates served as a social infrastructure through which practices spread, such as the adoption of 'poison pill' defences against hostile takeovers. The effect was that the research and researchers on interlocking directorates moved into the business schools. Don Palmer paved the way in 1980 by accepting a dual appointment in the department of sociology and business school at Stanford. He moved fully from sociology to the business school in 1990, and (from 1997) became a full professor and (in 2007–10, 2012) associate dean of the business school at UC Davis. Ron Burt accepted a chair in both business and sociology at Columbia University in 1990, and when Mark Mizruchi moved to Michigan in 1991, although based in sociology he also accepted a courtesy appointment as professor of business administration at the business school. Here, board interlock studies continued to flourish but no longer addressed the insurgent research questions that motivated the pioneers.

Conclusion

We studied the emergence of computer aided network analysis as an example of 'Mertonian' multiple discovery – the coming together of puzzles, social needs and developments internal to science. Mathematical graph theory provided a toolbox for the analysis of large networks. Both in the Netherlands and the United States this toolbox found an application in the study of corporate power. In the historical narrative, it became clear that one cannot understand this application without considering the personal and often political motivations of those who engaged in the first board interlock studies. Insurgent students pushed for a research agenda on corporate power, and found support with scholars who were keen to introduce and develop innovative methods. To be sure, not all the scholars in the first wave of computer aided corporate network analysis were radicals. It seems clear, however, that without the conviction of many of the key people in the field that there was something fundamentally wrong with the organization of economic power in our societies, the field would not have emerged as rapidly or had as much impact as it did. These ingredients came together at multiple

places at the same time, and we showed how this was the case in the Netherlands and the United States. The – at least in part – politically inspired research agenda not only helped to ignite the field of enquiry, but also hampered its further development by undermining the academic legitimacy of the research. As a result, the group of researchers in the Netherlands moved on to other topics and, in the USA, many of the more prolific interlocking directorate scholars moved to the business schools.

Of course, some scholars continued to work in the field of corporate power research. In the UK, John Scott (1986) carried on studying corporate elites throughout the 1980s and 1990s and the field also attracted researchers from Germany (Windolf 2002), Sweden (Ottosson 1992), Australia (Carroll and Alexander 1999), South Africa (Savage 1973) and Asia, but their work was less innovative in a methodological sense than the earlier studies. Early work in Canada by John Porter (1956) showed that interlocking directorates connected 170 of the most dominant Canadian firms, with key financial institutions inspiring a steady stream of corporate power research (Clement 1977). Bill Carroll started to study corporate elite networks in the early 1980s and consistently tracked their progress in the decades to come (Carroll 1982). This group, however, did not develop its own computer programs but instead used those of Richard Alba.¹⁵ At the turn of the century, Carroll reached out to Fennema and together they reproduced an earlier study by Fennema (1982) on international networks of banks and industry, which all of a sudden proved to be a rare empirical point of reference for the study of global corporate elites (Carroll and Fennema 2002).¹⁶

Our purpose was to compare the emergence of computer aided corporate network analysis at its multiple breeding beds in the USA and the Netherlands. Perhaps as interesting, but beyond the scope of this article, are the places where a similar development *did not* take place. The most prominent scholarly community in this respect is the group around French sociologist Pierre Bourdieu, which developed the highly influential field theory in relational sociology.¹⁷ These scholars saw the business elite as operating in an economic field dominated by competition over economic capital. Bourdieu's tripartite conceptualization of capital as cultural, economic and social led them to focus their attention on the issue of social mobility. They found that to gain a position in the economic field that provides corporate executives with power over economic capital, aspirant members of the corporate elite first had to accumulate cultural capital, thus giving a pivotal role to the educational system (Timans 2015: 61). This steered them in the direction of studying the reproduction of elites (a topic that sociologists picked up in Amsterdam in the late 1980s). Whereas the work on interlocks quickly attracted attention and became a popular subject for research in elite studies, field approaches picked up much more slowly. In his detailed study of these two research traditions in the Netherlands, Timans concluded that the concept of a field was so all-encompassing that it was difficult, if not impossible, to move it into other epistemological realms. Board interlocks did not suffer from that problem; they 'can be employed in various research practices and its [*sic*] use does not critically hinge on a particular theoretical interpretation' (Timans 2015: 244). Indeed, board interlocks remain an appreciated component of empirical research today in a wide range of fields of enquiry and theoretical traditions.

We understand that the historical narrative presented here is necessarily limited. It draws on the views of some and not others. It is neither a systematic nor an exhaustive analysis of the emergence of computer aided social network analysis. We only touch on one area in the broader development of social network analysis. Fortunately, others have written excellent studies that remedy many of these problems. Linton Freeman's (2004) *The development of social network analysis* (see also Freeman 1988) is the authoritative reference in this respect; another excellent introduction is John Scott's (1992) chapter on the development of network analysis. To this literature, we hope to contribute the notion of how personal motivations play a role in the 'discovery' of new fields of enquiry, and how in research on interlocking directorates we see a similar set of ingredients leading to the naissance of computer aided corporate network analysis on both sides of the Atlantic.

Today, there is an impressive body of scholarly work that has built on the groundbreaking pioneering studies discussed here. The network approach towards studying corporate elites and – more broadly – corporate governance remains popular. Recent studies from US business school scholars such as Mizruchi and Davis now underline the ongoing decline and fragmentation of corporate elite networks, thus leading to the fundamental question of whether networks still matter as much as they once did (Chu and Davis 2016; Mizruchi 2013). At the same time, a growing literature has established how the role of board interlock networks differs across time and space (David and Westerhuis 2014). The fragmentation thesis may be valid for some countries today, but not others. Scholars interested in the cohesion of corporate elites at the transnational level have found resilience in network connections rather than the decline witnessed at the national level (Carroll and Fennema 2002; Heemskerk et al. 2016a; Kentor and Jang 2004).

Recent work on board interlock networks at a much higher resolution than before offers a promising way forward. Rapid innovations in network analytical methods ('network science') on the one hand and a spectacular increase in the availability of data on the other have spurred new 'big data' corporate network studies. Early work has uncovered a complex global network of board interlocks with a clear multi-level structure that sometimes – but not always – disregards national borders (Heemskerk and Takes 2016; Heemskerk et al. 2016b). Related work on the global network of corporate ownership points to an unprecedented concentration of corporate control in the hands of a few financial institutions (Davis 2008; Fichtner et al. 2017; Haberly and Wójcik 2016; Vitali et al. 2011). Indeed, with a worldwide surge in inequality and the position of elites at the top of the distribution, corporate elite research is once again a 'hotbed' of activity (Mizruchi 2016: 8).

This recent step towards large-scale network analysis is promising, but ultimately an extension of the radical innovation that took place around 1970 – the emergence of computer aided corporate network analysis. What started out as a mathematician with a new method looking for a problem (Mokken in Amsterdam) and an anti-war activist looking for evidence to convince striking insurance workers that they were fighting the same enemy (Schwartz in Stony Brook), continues to spark intensive academic debate and exciting scholarly work.

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Notes

1. See also Rob Timans's (2015) recent dissertation on these 'hotbeds of early interlocks research', particularly his Chapter 2.
2. Many years later the criticsasters, among whom was an economist director of the Dutch Central Bank (DNB), blocked Mokken's entrance to the Royal Netherlands Academy of Science (KNAW). However, in 1994 the mathematicians appointed him to the executive committee of KNAW's Council for Mathematics.
3. Instead of an English version of the book, Mokken and Stokman decided to present and publish appropriate parts of their results in separate papers at conferences, mainly the 'Sessions of workshops of the European Consortium for Political Research'. This became the 'Traces of power' series ultimately consisting of five papers – 'Traces of power I: power and influence as political phenomena' (1974); 'Traces of Power II: interlocking directorates between banks and institutions in the Netherlands in 1969' (1974); 'Traces of Power III: corporate-governmental networks in the Netherlands' (1978); 'Traces of Power IV: the 1972 intercorporate network in the Netherlands' (1978); 'Traces of Power V: information and cooptation. Comparative analysis of two corporate networks in the Netherlands (1979)'.
4. Timans (2015: 38–44) gives an insightful review of early board interlocks research in the USA, placing it in the broader context of elite studies.
5. Email to the authors (24 January 2016).
6. Email to the authors (10 January 2016).
7. Email to the authors (6 April 2016).
8. This manuscript was eventually published as Koenig et al. (1979).
9. Fennema first presented this paper at a conference in Sussex in 1972 and it appeared in German in 1974 (see Fennema 1974).
10. Although Sweezy was critical of Berle and Means in the late 1930s, he later accepted their findings, most prominently in the second chapter of *Monopoly capital* and then in his debates with Fitch and Oppenheimer.
11. Later work led to a consensus that widespread management control was limited primarily to the USA and the UK.
12. Email to the authors (10 February 2016).
13. Personal communication with Frans Stokman (10 February 2016).
14. Email to the authors (30 January 2016).
15. Email to the authors (13 February 2017).
16. Fennema's original 1982 study attracted twice as many citations after 2001 as it received between 1982 and 2001.
17. Arguably, field theory is another example of multiple discovery (Timans 2015: 68). See also the remark by J. Clyde Mitchell (1974: 281) on the simultaneous application of social network techniques in anthropology.

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