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Integration and Isolation in the Global Petrochemical Industry: A Multiscalar Corporate Network Analysis

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abstract

The global petrochemical industry has long been characterized by stable patterns of Western corporate and geographic leadership, but since the early 2000s, the global playing field has changed significantly. China has overtaken the US and Europe as the world's largest petrochemical producer, and other emerging economies have become global petrochemical players. Combining insights from scholarship on global corporate elites, world city networks, and relational economic geography, this article examines patterns in the corporate networks of leading petrochemical corporations. The research is based on a multiscalar corporate network analysis, applying social network analysis to identify board interlocks, joint venture interlocks, and spatial interlocks between corporations. Through analyzing corporate networks across multiple scales, the research reveals patterns of both integration and isolation within the petrochemical industry. Isolation is evident in disconnected regional corporate elite networks, where the established North Atlantic corporate elite is interconnected through board interlocks, while corporate networks in Asia and other emerging economies remain disconnected. However, high levels of integration within the industry are also evident in an interconnected international company system formed through joint venture collaborations and in overlapping subsidiary networks centered on petrochemical hubs around the world. The article argues that the results demonstrate a combination of resilience and change, or path dependence and contingency, in patterns of corporate power and collaboration. Western company networks still form the social and spatial backbone of the industry, but these have been challenged by emerging strategic centers and isolated elite networks in other parts of the world. This article contributes to debates on industrial corporate elites, multiple globalizations, and the multipolar global economy.

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Throughout the twentieth century, the global petrochemical industry was dominated by a handful of Western oil and chemical corporations, with strong barriers to entry, concentrating production in Western Europe and North America (Galambos, Hikino, and Zamagni 2007; Chandler 2009; Reubold, Milmo, and Todd 2016). However, since the 2000s the regional balance of production has been changing. China has rapidly emerged as the largest petrochemical producer in the world, overtaking the US and Europe in the decade of 2006–16 (European Chemical Industry Council [CEFIC] 2017). Does the recent surge of petrochemical production in China and other emerging economies challenge the long-standing resilient configuration dominated by Western multinationals?

Corporate elite networks, particularly board interlock ties, have been widely researched within the global economy and are associated with the exercise of power, consensus-building, and market control (Fennema and Heemskerk 2018; Sapinski and Carroll 2018). Building on this, Buch-Hansen and Henriksen (2019) consider within-industry board interlocks as a less binding form of market control in the European chemical industry throughout the twentieth century, supplementing episodes of more binding forms like cartels and corporate mergers. Regional corporate elite clusters play an important role in the global political economy, with long-standing connections between Europe and North America, and competing corporate elites in emerging economies (Heemskerk and Takes 2016). Despite increasing evidence of a multipolar global economy, research has shown that corporate elites in China and Asia have overall remained relatively isolated from incumbent Western corporate elites (de Graaff 2012; Heemskerk and Takes 2016). In this article, we take a broader view on corporate interlocking and present a multiscalar corporate network analysis of the global petrochemical industry, drawing on methods of social network analysis to examine three spaces for corporate interaction: corporate boards, joint ventures, and co-location of subsidiaries. We pose two research questions: (1) To what extent are the current corporate networks within the global petrochemical industry integrated or isolated? (2) What do these corporate networks tell us about patterns of power and collaboration?

To address these questions, we have developed an analytical approach drawing on methodologies of network analysis applied in the *global corporate elites* and *world city networks* literature. Although

both literatures are largely separate, we suggest they can be meaningfully integrated based on a relational economic geography perspective. This subfield of economic geography rapidly grew since the late 1980s based on an interest in analyzing the effects of globalization and global interdependencies on regional-economic development and innovation, applying a relational, multiscalar, microlevel economic agency perspective (Grabher 2006; Glückler 2007; Murphy 2018). While several theorists have warned that the centrality of intentional human agency must be the focal point (Grabher 2006; Glückler 2007; Sunley 2008), we believe that, particularly at the global level, networks still provide a useful analytical perspective for understanding power configurations. Networks are both structural and relational, "being continually shaped and reshaped by the action of actors who are in turn constrained by the structural positions in which they find themselves" (Nohria 1992, 7). They form an *infrastructure* through which agency and power can be exercised by individual agents, but as a whole, they also constitute structural power relations in which inequalities and exclusions exist, so-called emergent network relationships (Dicken et al. 2001).

We examine corporate networks of the global petrochemical industry, using a judgment sample[1] of the top ten petrochemical corporations and four additional corporations from emerging economies, based on corporate data collected between December 2017 and July 2018. According to industry analyst Eramo (2018), the year 2018 represented "the sixth year of an extended upcycle in global chemical markets—characterized by robust demand, tight supply, and strong profitability." Thus, our data capture the end of a cyclical period of expansion and growth across all competitive regions of the globe before the subsequent downturn due to overcapacity in 2019. Our aim is to investigate patterns of integration and isolation within this industry, which has undergone considerable structural transformation in recent decades. We build on recent insights and methodological developments in the global corporate elite network and world city network literatures. From the first field, we incorporate ideas on the resilience of the Atlantic ruling class (van der Pijl 1984; Heemskerk, Fennema, and Carroll 2016), the isolation of Asian and emerging economies' corporate elites (Carroll 2009), the role of policy-planning institutes as integrative nodes for corporate elites to exert influence in political domains (Carroll and Sapinski 2010), and the opening up of social corporate network research toward other forms of interlocks such as joint ventures (de Graaff 2011). From world city network analysis, we borrow ideas on multiple globalizations (Sigler and Martinus 2016), gateway cities (Scholvin, Breul, and Diez 2019) and the importance of tax havens and offshore financial centers (THOFCs) in company networks (Sigler et al. 2020).

Our analysis shows important differences between corporations from the North Atlantic petrochemical heartland, those from Asian advanced economies, and those from emerging economies; but our analysis also shows differences within these groups, including interconnected versus closed elite networks, the convergence of interests in joint venture companies, integrated subsidiary networks, and the significance of particular cities as powerful hubs for the flows of capital. We interpret the findings of our multiscalar corporate network analysis through the concepts of contextuality, path dependence, and contingency (Bathelt and Glückler 2003) in relation to regional changes in power identified through industry data collection and within existing business histories of the development of the petrochemical industry (Galambos, Hikino, and Zamagni 2007; Chandler 2009; Reubold, Milmo, and Todd 2016). Our

[1] A judgment or expert sample is a type of random sample that is selected based on the opinion of an expert and thus subject to some degree of bias. We chose this method of sampling due to the vast size and complexity of the industry, and we outline our methodology in detail later in the article.

findings also relate to wider debates about competing corporate elites and places within an increasingly multipolar global political economy (Amin 2013; Heemskerk and Takes 2016). In the next section, we present a brief overview of the history of the petrochemical industry, followed by our analytical approach combining methodologies for studying global elite networks and world city networks. Subsequently, the data and methods will be outlined and described, followed by a description of the results and a final discussion section.

The Global Petrochemical Industry

The petrochemical industry specializes in the production and trade of petrochemicals, which are derived from oil and natural gas, forming the basis of thousands of everyday products including plastics and other polymers. Petrochemicals account for 90 percent of total feedstock demand in chemical production today (International Energy Agency [IEA] 2018), and therefore the terms *petrochemical* and *chemical* industry are often combined or used interchangeably. The petrochemical industry is

situated between the *upstream* oil and gas industry and the *downstream* plastics industry. The main petrochemical players include different kinds of companies: vertically integrated multinational oil companies, multinational chemical companies, vertically integrated national oil companies, and specialty chemical companies. As the IEA (2018, 11) argues, the "diversity and complexity of this sector means that petrochemicals receive less attention than other sectors, despite their rising importance … [as] the fastest growing source of oil consumption." We aim to redress the balance, focusing our attention on the complex networks of this industry.

The modern petrochemical industry emerged during the Second Industrial Revolution of the late nineteenth and early twentieth centuries, alongside other capital-intensive industries such as primary metals, electrical machinery, and automobiles (Galambos, Hikino, and Zamagni 2007). The first petrochemical plants were built by major oil companies and were usually located close to refineries, since the main intention was to find uses for the by-products of oil refining to increase profit margins (Mitchell 2009; Clews 2016). Initially German, Swiss, and British producers dominated the world markets, but during the First World War the US became an important new player, boosted by its abundance of nonrenewable natural resources and the sheer size of its internal market (Chandler 2009).

The Second World War and the postwar economic recovery brought the petrochemical sector into an era of large-scale technology-driven production and commercialization, closely linked with scientific research, starting in the US and soon afterward Western Europe and the new petrochemical power Japan (Chandler 2009; Reubold, Milmo, and Todd 2016). By the 1960s, the petrochemical industry had emerged as an industry of its own, dominated by five postwar leaders: the US, Germany, France, the UK, and Japan. In this period, states intervened extensively, with industrial policies promoting large-scale chemical producers (Buch-Hansen and Henriksen 2019).

In the 1970s and 1980s, two politically induced oil shocks led to radical uncertainty, increased costs of production, a slowdown of the growth rate of consumption, and a downsizing and reorganization of the petrochemical industry (Galambos, Hikino, and Zamagni 2007). While the initial response to the oil crisis was the formation of (illegal) cartels, particularly in Europe, these were terminated by regulatory developments promoting liberalization (Buch-Hansen and Henriksen 2019). Together with the entrance of new Asian challengers from Taiwan, Saudi Arabia, and South Korea, this led to intensified global competition. Further globalization throughout the 1990s and 2000s

promoted foreign direct investment by major petrochemical companies, while domestic petrochemical producers from emerging economies also started to invest heavily, aiming at self-sufficiency. These evolutions contributed to a large restructuring process of mergers and acquisitions, and further geographic agglomeration of production among major Western companies (Reubold, Milmo, and Todd 2016).

However, until the end of the twentieth century, production and corporate leadership remained concentrated in the US, Western Europe, and Japan (Clews 2016). Despite globalization, the petrochemical industry had been remarkably stable, especially when compared with other knowledge-based, high-technology industries (Chandler 2009). The major enterprises still included some of the traditional leaders that had secured their market dominating positions well before the Second World War (e.g., BASF) or in the postwar petrochemical revolution (e.g., Mitsubishi Chemical), joined by the petrochemical divisions of established oil companies (e.g., ExxonMobil). Galambos, Hikino, and Zamagni (2007) argue that the traditional leading firms had for the most part successfully transformed themselves from producers of upstream, basic-chemical commodities into leaders in the manufacturing of downstream, fine, and specialty chemical products. The firms had also sought access to resources and national markets and economies of global scale, and in so doing, had preserved their dominant position.

This traditional geographic configuration has been disrupted over the past two decades, with a dramatic increase of production in areas with competitively priced feedstock, particularly in Asia. This has led to structural changes, with site closures in the more established and mature European markets (Clews 2016). China, the most important new player, has overtaken the US and Europe as the largest petrochemical producer, and other emerging economies are expanding petrochemical production rapidly. While the EU, NAFTA,[2] and Japan still held a combined share of 59.5 percent in world chemicals sales in 2006, this share plummeted to only 35 percent in 2016 (CEFIC 2017). In the same decade, China grew to be the largest petrochemical producer, with its share tripling from 13.2 to 39.6 percent. The only two other regions whose share increased were India (from 2.0 to 2.3 percent) and what the CEFIC calls the *Rest of Asia*[3] (from 10.3 to 12.1 percent). These numbers show that petrochemical production has been undeniably moving away from its traditional heartlands, but as our analysis shows, this does not mean that patterns of corporate leadership are also shifting at the same pace. These changes have also led to a more diverse petrochemical playing field, with different combinations of upstream and downstream businesses, and varying global and regional ambitions.

Global Corporate Networks

In this study we bring together two strands of literature that explore issues of hierarchy and networking in the structures of global economic power: (1) the global corporate elite network literature focuses on relations between firms, formed by their directors; and (2) the world city network literature focuses on relations between cities, formed by firms and subsidiaries located in these cities. While the roots of both literatures go further back in time, empirical studies started to emerge from the 1980s onward, based on a theorization of two phenomena in the globalizing capitalist economy: the emergence of a transnational capitalist class (Sklair 2001; Robinson 2004) and of global cities (Friedmann 1986; Sassen 1991). Sklair (2001) and Robinson

[2] North American Free Trade Agreement, a free trade bloc consisting of the US, Canada, and Mexico.
[3] Asia minus China, India, Japan, and South Korea.

(2004) theorize that national identities of corporate elites would be replaced by a common transnational identity with a shared sense of economic interests and an enhanced capacity for unified political action, forming a transnational capitalist class "tied to globalized circuits of production, marketing and finances unbound from particular national territories and identities and with interests in global over local or national accumulation" (Robinson 2004, 47). At the same time, Friedmann (1986) and Sassen (1991) observe the emergence of *global cities* or *world cities*, being the *basing points* in the spatial organization of global production and markets, with highly concentrated *command and control functions*. Both literatures started to explore the existence of these phenomena from the 1980s onward, mainly based on all-industry samples of the world's biggest firms. Partly in response to criticisms, they gradually expanded their scope, sought integration with other theories, and evolved toward more regionalized, sectoral, and qualitative approaches. While a lot of progress has been made and some authors have tried to integrate both research fields, we contend that there are still interesting opportunities missed of combining both approaches. In the remainder of this section we give a brief overview of both literatures and outline why we want to combine their approaches.

Global Elite Networks—Social Corporate Interlocking

A particularly popular application of social network analysis has focused on the corporate boards of multinational corporations, and the connections that directors in these boards have with other corporations through *interlocking directorates* ("when a person affiliated with one organization sits on the board of directors of another organization" [Mizruchi 1996, 271]). It is the combination of such corporate interlocks that underpins Domhoff's (1967) prediction of a *corporate community* or, at the transnational level, Sklair's (2001) idea of a *transnational capitalist class*.

The concept of a *transnational capitalist class* was first theorized at the end of the twentieth century, but computer-assisted empirical research on the transnational network of interlocking directorships had already taken off in the 1970s and 1980s (Fennema and Heemskerk 2018). Fennema's (1982) groundbreaking study on interlocks among the largest firms in North America, Europe, and Japan showed that the globalization of capitalism did not go hand in hand with the expected internationalization of corporate elite social structures. There were signs of a sparse integrated transatlantic network, but it connected resilient national clusters. Later studies pointed to significant progress in transnational elite formation (particularly in Europe), a further consolidation of the transatlantic connection, and a more horizontal structure of corporate interlocking with a larger number of *single linkers* (Carroll and Fennema 2002; Carroll, Fennema, and Heemskerk 2010; Heemskerk, Fennema, and Carroll 2016). At the moment, a transnationalist class is very far from being realized on a global scale (Burris and Staples 2012). Instead, a more circumscribed version exists, in the form of a cohesive and consolidated *Atlantic ruling class* (a term coined by van der Pijl (1984)), which forms a bridge between resilient national and regional networks. Other parts of the world (including Japan and China) remain only marginally connected (Carroll 2009; Heemskerk and Takes 2016).

While quantitative studies largely agree on the spatial layout of the corporate elite network, there is a variety of views on how these interlocks should be interpreted and why they exist in the first place (Mizruchi 1996). The emergence of empirical research was mainly based on two complementary perspectives: the resource dependence model and the class hegemony model. The first theory sees corporate interlocks as

interorganizational phenomena, serving the interests of corporations. According to this interpretation, board interlocks are formed for instrumental purposes of control, coordination, and/or allocation (Carroll 2007). They would help reduce economic uncertainty and secure resources from banks and suppliers. Though most evidence suggests that directors are mainly recruited for reasons other than interorganizational strategies, for example, their experience or geographic proximity (Davis, Yoo, and Baker 2003), corporate interlocks clearly demonstrate a system of exchange that can have an effect on corporate governance. Dozens of studies have documented the influence of shared directorships on choices about corporate strategy and structure (see Davis, Yoo, and Baker 2003). It follows that interlocks can have implications for market control. As Buch-Hansen and Henriksen (2019, 25) describe, regardless of why a board interlock is formed, "it may simultaneously come to have implications related to market control if it happens to directly or indirectly connect competing companies." The second theory, the class hegemony model, sees corporate interlocks as intraclass and interpersonal phenomena, serving the interests of the capitalist class. According to this theory, corporate interlocks are a means to maintain class cohesion, integrate new elites, and facilitate class-wide political action by constituting meeting points for directors (Carroll, Fennema, and Heemskerk 2010). The social interaction also functions to create or solidify shared identities and worldviews, common understandings, and mutual trust (Burris and Staples 2012). As such, corporate interlocks enable the corporate community to define and pursue its common interests in maintaining the status quo of concentrated corporate power (Sapinski and Carroll 2018).

In recent years, the global corporate elite network literature has expanded in scope and methodology. In response to the common criticism that corporate board interlocks through other companies constitute only one form of interlocking, some studies have focused on connections through policy planning institutes (Carroll and Carson 2003; Carroll and Sapinski 2010). These institutes were found to be important nodes for integrating corporate elites, constructing consensus within business communities, and enabling corporate capital to project influence in political domains. There have also been several regional or sectoral studies based on small samples of companies, particularly in the controversial oil and fossil fuel sector. For example, de Graaff (2012) examined the elite networks created through affiliations of the directors of the world's largest oil companies with other corporations, policy planning bodies, and the state. She found that the increased cooperation between Western international oil companies and non-Western state-owned oil companies had not yet translated into increased integration of their elite networks. Other studies have moved beyond board interlocks and have examined other ways of corporate interlocking that serve information flow, elite integration, and more explicit collaboration. de Graaff (2011) shows that her sample of five state-owned energy companies was substantively integrated with international oil companies through joint ventures, contracts, and other forms of agreements and collaborations, in contrast to the lack of integration of their elite networks. Finally, in a unique example of a social network analysis of the chemical industry, Buch-Hansen and Henriksen (2019) analyze the history of corporate board interlocks, cartels, and mergers and acquisitions in a sample of European chemical companies. The authors argue that these three phenomena represent means of (implicit) market control that became popular in specific time periods in response to changing political–economic conditions.

In our analysis, we focus on corporate interlocking through corporate boards and one type of interfirm alliance, namely, joint ventures. Joint ventures have been defined as legally and economically separate organizational entities created and governed by two

or more parent organizations that collectively invest financial, as well as other resources, to pursue certain objectives and share returns and risks (Anderson 1990). They usually have a limited scope of operations and a fixed life span. Companies typically pursue joint ventures for one or more of the following reasons (Kent 1991; Yan and Luo 2016): to gain access to new markets, to share risks for major investments or projects, to tap outside resources, to build competitive strength at significantly reduced costs, to gain scale efficiencies and greater market power by combining assets and operations, to manage rivalry in an industry by turning potential competitors into allies, and to meet host country requirements. We argue they can complement corporate board interlocks in functioning as a means of control and coordination between firms or as a communication channel contributing to elite integration.

Our study adds to the literature by analyzing corporate board interlocks and joint venture interlocks in a judgment sample of the petrochemical industry. However, to have a more nuanced view on integration, isolation, and power configurations in this industry, we want to account for relational proximity—interpreted as the degree to which individuals, firms, and communities are "bound by relations of common interest, purpose, or passion, and held together by routines and varying degrees of mutuality" (Murphy 2006, 430)—*and* spatial proximity, that is, co-location in geographic space. Therefore, we complement our exploration with an assessment of the spatial integration (or interlocking) of global petrochemical corporations.

World City Networks—Spatial Corporate Interlocking

While the idea of a *transnational capitalist class* has inspired network analysis of social interlocks *between* corporations in the global economy, the idea of *global cities* has fueled network analysis of city interlocks formed *through* corporations. Sassen (1991) points to advanced producer service firms as key agents for the servicing and controlling of the cross-border operations of global firms, which means the clustered network of advanced producer services could be considered a proxy for the management and governance of global operations and be used to map the world city network. This theorization was followed by a *quantitative* or *empirical* turn, starting from the hierarchical office networks of global advanced producer service providers creating connectivity in the world city network (Taylor 2001). The resulting Interlocking World City Network Model (IWCNM) led to numerous contributions (Taylor 2004; Hennemann and Derudder 2014; Derudder and Taylor 2016). An important criticism of the IWCNM—similar to the criticism of board interlocks and echoing the structure versus agency debate in the relational economic geography—is that it solely detects the "channel system of flows and its relevant intersections" (Krätke 2014, 128), instead of addressing the question of what these producer service links exactly *mean*. This has led to calls for a refocus on the actual flows between producer service firms and multinational corporations and qualitative studies on individual agency and practice (Parnreiter 2014; Watson and Beaverstock 2014).

The IWCNM model is also criticized for its narrow focus on the role of cities as centers of specialist financial and corporate services (Krätke 2014). Some authors have expanded the scope by focusing on subsidiary networks of multinational firms from a broad range of economic subsectors (Alderson and Beckfield 2004; Wall, Burger, and Van der Knaap 2011; Wall and van der Knaap 2011). Only recently the analysis of networks of distinct industrial subsectors has taken off, based on the idea that urban positionality differs from one network to another. This idea explains the existence of *multiple globalizations* and *globalizing cities*—cities that are not truly global in all

economic sectors, but that are characterized by differing profiles of globally connected economic functions (Krätke 2014). The empirical research on multiple globalizations has pointed to particular sector-specific territorial configurations that are the result of path dependence, resource availability, market access, geopolitics, sectoral differentiation and firm- and industry-based locational strategies (Sigler and Martinus 2016). Very diverse alternative geographies of globalization have been mapped, for example, for the pharmaceutical and biotechnology industry (Krätke 2014) and for the energy sector (Martinus and Tonts 2015).

Another recent development, building on the idea of multiple globalizations, is the attempt to integrate the world city network with global production networks in *regionalizations* of specific industries (Brown et al. 2010). The main idea is that specific *gateway cities* connect regional hinterlands to the global flows of the world city network through the initial (upstream) segments of global production networks (Breul and Diez 2018; Scholvin, Breul, and Diez 2019). Finally, THOFCs have also recently been identified as a specific kind of nodes in global firm networks. Sigler et al. (2020) showed that the role of place in decision-making has partly been reoriented from supply- or demand-side advantages to purely financial considerations, with global firm networks mimicking geographies of taxation.

The concepts of globalizing cities, gateway cities, and THOFCs can be applied to construct the alternative geography of the petrochemical industry's spatial organization. However, we want to take the methodology one step further, inspired by Yang and Dong's analysis of the spatial strategies of individual oil companies based on headquarter subsidiary data (2016). Instead of constructing a network of intercity links, based on headquarter-subsidiary ties within a large sample of multinational corporations, we construct a network of interfirm links based on *spatial interlocks* (i.e., colocation of subsidiaries) in a small sample of multinational corporations. This approach leads to a spatial proximity perspective on interorganizational collaboration and competition.

Toward Integration—Relational Economic Geography

The corporate elite network literature shows how companies are connected through social spaces of interaction, while the world city network literature shows how they are connected through physical spaces of interaction. We see both literatures as complementary in revealing different sets of relations between firms and argue that some concepts from the relational economic geography literature are particularly useful to integrate and interpret our research findings. First, the combined analysis of different social and spatial corporate interlocks is supported by the interpretation of proximity as a multidimensional concept that involves both relational and spatial proximity (Rodríguez-Pose 2010). While relational proximity, involving translocal relationships, has grown in importance with increasing globalization, spatial or geographic proximity still plays a role in many industries. This is not only because of classical location conditions but also because of reduced transaction costs and enhanced capabilities for knowledge transfer and organizational and technological learning (so-called untraded interdependencies) (Bathelt and Glückler 2003; Murphy 2018). Second, the structure versus agency debate, central to the relational economic geography literature, motivates our methodological approach to networks. Some relational economic geography scholars have criticized research that focuses on network structure and actor positionality instead of intentional human agency (Grabher 2006; Glückler 2007; Sunley 2008). Although we appreciate this criticism, we contend that network analysis still provides

a useful analytical perspective to understand the relational *infrastructure* through which agency can be exercised by individual agents and which as a whole also constitutes structural power relations (Dicken et al. 2001).

We interpret our multiscalar corporate network analysis as a snapshot in time, simultaneously reflecting past events, present interdependencies, and possible future pathways. In our analysis, we draw on three concepts from relational economic geography for interpreting economic action and interaction, following Bathelt and Glückler (2003): (1) contextuality, (2) path dependence, and (3) contingency. These relational concepts have been empirically applied in a variety of contexts, from industrial cluster evolution (Li, Bathelt, and Wang 2011), over foreign direct investment in peripheral regions (Dawley 2007), to peri-urban farmer adaptation (Clark and Munroe 2014). By using these concepts to interpret three different interpretations of corporate networks, we aim to be more nuanced than other studies of world cities and corporate elite networks. At the same time, we emphasize the importance of network analysis for advancing innovative perspectives within relational economic geography, which seek to engage with both structure and agency to understand power configurations and inequalities in the global economy.

Methodology

We have analyzed corporate board interlocks, joint venture interlocks, and spatial interlocks in a sample of global petrochemical corporations. The analysis was restricted[4] to the top ten chemical corporations in 2016 and—because the top ten was still dominated by established companies—four additional top fifty corporations from emerging economies (Table 1). These fourteen companies provided a diverse sample with several corporations based in the traditional petrochemical powers of Western Europe and the US, some Asian entrants from the second half of the twentieth century (based in Japan, Saudi Arabia, and Taiwan), and corporations from different emerging economies (notably China).

For the corporate board interlocks, data on the composition of the boards of directors and directors' affiliations were extracted from Orbis (Bureau van Dijk), a database with information on companies worldwide. Affiliations did not only include membership of other boards of directors but also membership of advisory boards, scientific boards, and boards of trustees, or purely operational positions. Additionally, the annual reports and corporate websites of the fourteen companies were consulted to cross-check and complete the data, together with online open access corporate databases such as Bloomberg and Hoovers. Finally, the websites and annual reports of affiliated companies and organizations were used to confirm the actual affiliations of the fourteen corporate boards. Data collection took place between April and June 2018 and thus reflects the composition of the boards and their affiliations at that time.

For the joint venture interlocks, data were collected in the first place from the annual reports and corporate websites of the fourteen corporations. Also, joint operations were included, an often-used strategy in the oil and gas sector in which two companies come together and start an operation jointly, without creating a separate business entity. Data were cross-checked and completed using online open access corporate databases (Bloomberg, Hoovers). A final verification process included a Google search of every combination of two companies together with the keyword *joint venture*. This

[4] For reasons of data accessibility and limited resources, we had to confine our sample to fourteen corporations.

Table 1

Sampled Companies, with Data Extracted from the List of Top Fifty Chemical Companies in 2016 according to Chemical & Engineering News *(https://cen.acs.org/sections/global-top-50.html)*

2016 Ranking	Change from 2007	Company	Headquarters Location	Chemical Sales ($ Million)
1	**+1**	DowDuPont	US	$67,837
2	**−1**	BASF	Germany	$60,654
3	**+3**	Sinopec	China	$42,815
4	**+3**	SABIC	Saudi Arabia	$30,986
5	**+5**	Formosa Plastics	Taiwan	$27,141
6	**−1**	ExxonMobil	US	$26,058
7	**+6**	LyondellBasell	Netherlands	$24,624
8	**−4**	INEOS	Switzerland	$23,530
9	**+3**	Mitsubishi Chemical	Japan	$23,358
10	**+8**	Air Liquide	France	$19,554
…	…	…	…	…
17	***+4***	*Reliance Industries*	*India*	*$13,769*
18	***+18***	*Braskem*	*Brazil*	*$13,692*
42	***−1***	*Sasol*	*South Africa*	*$7,148*
48	***NA***	*PTT Global Chemical*	*Thailand*	*$6,151*

Note: For the merged companies DowDuPont and LyondellBasell the highest ranked partner in 2006 was used for the calculation.

way, most joint ventures between the fourteen corporations should have been discovered, as well as important joint ventures with other companies. Data were collected over the course of June and July 2018 and reflect the situation at that moment.

For the spatial interlocks, the subsidiary networks of the fourteen corporations were exported from Orbis. For each corporation, this network contained all majority-owned subsidiaries. Since the spatial interlocks analysis focuses on geographic proximity, an important preparatory step was the cleaning and coding of the location data. Subsidiary locations registered in Orbis were considered to be correct, and other corporate databases or Google were only used to find the location of subsidiaries with missing information. Finally, locations were aggregated to the larger metropolitan area that they are part of, if applicable.[5] These standardized agglomeration data were used in further analysis. Primary data were extracted from Orbis in December 2017 and reflect the situation at that moment.

Social and spatial interlocks were analyzed using the network analysis software UCINET (Borgatti, Everett, and Johnson 2018). Based on the corporate board interlocks, the joint venture interlocks, and the spatial interlocks, we have created three one-mode company by company networks with valued ties based on the strength of the interlocks. The corporate board interlock network was transformed from the two-mode affiliation–director network. All identified interlocks were indirect interlocks, whereby directors of two corporations meet each other in a third board. We present two diagrams. One is based on indirect interlocks through another company, mainly through shared directorship in the board of directors. A second diagram presents indirect connections through the board of directors or board of trustees of policy-planning institutes, trade associations, charities, think tanks, schools, and universities as well as through state affiliations. The joint venture interlock network was transformed from the two-mode company–joint venture network. We present two diagrams: one based on direct interlocks (a joint venture between two companies of our sample),

[5] This is a common approach in World City Network analysis, where boundaries of world cities are not defined by administrative or political criteria, but rather by patterns of interaction.

another based on indirect interlocks (joint ventures with the same external company). The spatial interlock network was transformed from the two-mode company-city network. The extent of the co-location of subsidiaries of two companies was calculated as a measure of their spatial integration. We present two diagrams: one based on the absolute values (the number of locations in common), another based on relative values (the absolute number divided by the maximum number of possible meeting points of the two companies).

To visualize the six resulting networks, we have applied metric multidimensional scaling (MDS) based on the tie strength as a proximity matrix. This means the optimum two-dimensional representation of the network is sought in which companies with stronger ties will be located closer to each other, while weaker ties will push companies away from each other. Together with adapting tie width according to the strength of the interlocks, this scaling provides an additional aid in making sense of the network visualization. Finally, the spatial interlock network is complemented with a map of the points of integration—or *meeting points*—between the subsidiary networks of the six companies headquartered in the traditional petrochemical powers of Europe and the US, and the eight companies from other parts of the world.

Results: Interlocking Networks in the Petrochemical Industry

Figure 1 (left side) shows the network of indirect corporate board interlocks through other companies in 2018. The network consisted of one component of six interconnected companies, and eight individual companies that were not connected to any other company. It is striking that in our small sample, apart from INEOS,[6] all companies based in Europe and the US were interconnected. These are all companies whose roots go back to the early days of the petrochemical industry. Brazilian Braskem was the only company from outside the North Atlantic petrochemical heartland that participated in this interconnected component. However, the Braskem link to ExxonMobil was not a particularly strong one, with Braskem director Gesner Oliveira as a member of Uber Technologies' policy advisory board and ExxonMobil director Ursula Burns as chairman of Uber Technologies' board of directors. The five other members of the component were interconnected through seven corporate interlocks, of which the French-German Air Liquide-BASF connection stood out as particularly strong with three interlocks (which is why they are positioned close to each other in the diagram). Of these seven corporate interlocks, five consisted of shared directorships of another company's board (BP, JPMorgan Chase, Siemens, Cicap, and TechnipFMC), one consisted of two similar senior advisory positions in the same company (EW Healthcare Partners), and one consisted of a board membership and a CEO position (Daimler).

The right side of the diagram in Figure 1 shows interlocks based on affiliations with policy-planning institutes, trade associations, charities, think tanks, schools, universities, and states. It is the same group of companies (this time without Braskem) that was strongly interconnected in one component, while all other companies were not connected to any other company of our sample. Within the interconnected component, three US-based policy-planning organizations played a crucial role: the Business Council, the National Petroleum Council, and the Business Roundtable. They linked three corporations that are based in the US (ExxonMobil and DowDuPont) or have

[6] INEOS is privately owned and has no board of directors.

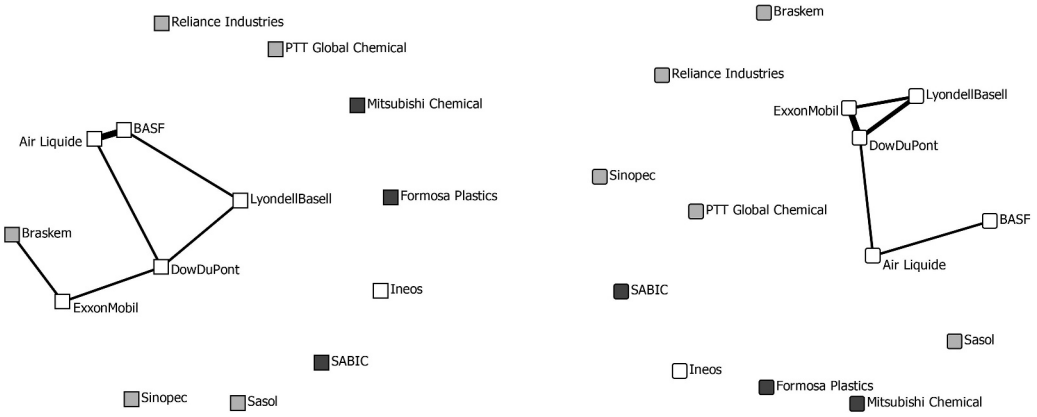

Figure 1. Corporate board interlock network based on indirect interlocks through other companies (left) and through policy-planning institutes, other organizations, and states (right). Note: White squares: companies based in Europe and the US; dark grey squares: post–World War II Asian entrants; light grey squares: companies from emerging economies. Tie width represents the number of interlocks, and metric multidimensional scaling was applied.

partly American roots (LyondellBasell). The other ten interlocking organizations were only linked to two companies. There also existed a large difference in the number of interlocking connections each company had. With several directors active in interlocking, DowDuPont had fifteen single connections to interlocking third parties, while BASF had only two. Finally, the thirty-six interlocking ties were made by only fourteen directors, with eight of them responsible for multiple ties. The biggest linkers were DowDuPont's CEO Andrew Liveris[7] with six interlocking connections, and LyondellBasell's CEO Bhavesh Patel with five.

In summary, integration and isolation in the network structure composed by interlocking directorships can be interpreted through the concepts of contextuality, path dependence, and contingency (Table 2). We have found a highly integrated North Atlantic component, with very few ties to the rest of the world. On one level, this supports the findings of transnational capitalist class studies (Carroll 2009; Heemskerk, Fennema, and Carroll 2016), but it can also be interpreted through the lens of path dependence within the petrochemical industry, with the current corporate networks forming the legacy of decades of Western leadership of the industry. The lack of integration between Western and non-Western elites, also found for the oil industry (de Graaff 2012; de Graaff and van Apeldoorn 2017), tells us something about existing social power structures and opportunities for exercising individual agency, but it provides a very partial view. Not only are there many other ways through which elites can connect, but the lack of integration should also be interpreted contextually. For example, the leading petrochemical players in China and Brazil—vertically integrated and tied to (majority) state-owned oil companies—have long been driven by regional ambitions of market self-sufficiency and are only recently aspiring more global ambitions, which might be reflected in their board composition (Carlos Zalaf Caseiro and Masiero 2014). Finally, the discovery of links that deviate from traditional patterns, such as the one between Braskem and ExxonMobil, shows that petrochemical

[7] Data were collected in April 2018, just before Andrew Liveris officially stepped down as director and CEO.

corporate board networks are contingent, building on existing structures but moving in new directions.

The findings of our corporate board network analysis are further nuanced by our joint venture network analysis. The left diagram in Figure 2 shows that in 2018 only three corporations (Reliance Industries, Braskem, and Formosa) did not have any verifiable joint venture with another company of our sample. All other companies formed one integrated component, with Chinese state-owned Sinopec clearly taking the most central position, linking to seven other companies of our sample through twelve joint ventures (all located in China). The Thai state-owned company PTT Global Chemical had a similar profile, connecting to three Thailand-based joint ventures with more established petrochemical companies. Overall, we could not find any joint ventures between the five companies from emerging economies (light grey squares), and apart from a strong tie between BASF and DowDuPont composed of six joint ventures,[8] it was not a popular way of integrating Western companies either.

Within our small sample, joint ventures are a clear means of integration between Western companies and companies from emerging economies (thirteen of twenty-seven identified joint ventures). A possible incentive for Western multinationals is to gain access to new markets and resources through these joint ventures, while emerging economy partners might be looking to acquire technology and know-how. This technology transfer idea lies at the basis of China's policy of attracting direct foreign investment with cheap labor and tax incentives, with a preference for joint ventures (Yan and Luo 2016). However, other strategic aims like sharing risk for major investments and gaining scale efficiencies may play an equally important role. Although it goes beyond the scope of this article to discuss the details of individual joint ventures, the concentration of joint venture relationships on some emerging economy corporations warrants further investigation.

The right diagram in Figure 2 shows the corporate interlock network based on joint ventures with third companies. This network shows one strongly integrated component, of

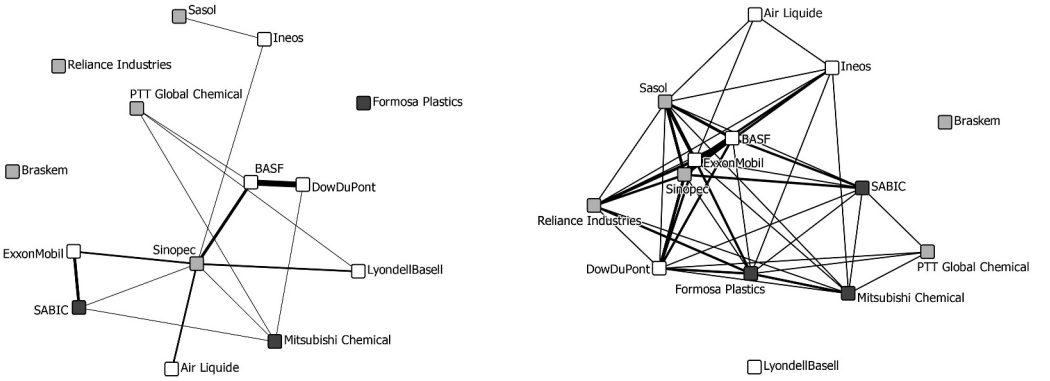

Figure 2. Joint venture interlock network based on direct joint venture integration (left) and through joint ventures with the same external companies (right).
Note: White squares: companies based in Europe and the US; dark grey squares: post–World War II Asian entrants; light grey squares: companies from emerging economies. Tie width represents the number of interlocks, and metric multidimensional scaling was applied.

[8] Five of these relate to the same DowDuPont-BASF plant in Antwerp.

which only Braskem and LyondellBasell are excluded. Given that LyondellBasell is part of the direct joint venture network, Braskem is the only company that remains isolated. The metric multidimensional scaling applied to the network shows that ExxonMobil and Sinopec shared the most joint venture partners (seven) followed by ExxonMobil-BASF (five), ExxonMobil-Sasol (four) and BASF-Sinopec (four). A substantial overlap in the choice of joint venture partners thus connected companies from emerging economies with Western companies, as such forming an integrated global industry. Some joint venture partners were very prominent: Chevron had joint venture relations with six different companies of our sample; BP and Total had joint venture relations with five companies; and Shell, PetroChina, and Asahi Kasei had joint venture relations with four companies. Apart from Asahi Kasei, these are all major oil and gas companies, pointing to the close ties between the petrochemical industry and the oil and gas industry.

In summary, while the corporate board interlock analysis showed little integration between Western and non-Western corporate elites, our joint venture analysis revealed that most non-Western corporations were part of an integrated company system through either direct or indirect joint venture relations. The network demonstrates a higher degree of contingency and a lower degree of path dependence, as compared to the corporate board interlock network (Table 2). The fixed life span and limited scope of operations of joint ventures does not require the same level of personal trust; instead, strategic business aims seem to prevail, and new joint venture relationships can be established quickly. These findings are in line with de Graaff's (2011) finding on the substantial integration of non-Western state-owned energy companies with international oil companies through joint ventures and other contracts and collaborations, in contrast to the lack of integration of their elite networks. Despite the fixed life span of joint ventures, path dependence still plays a role. For example, BASF has operated in China for more than 130 years,[9] and it is therefore no surprise it is involved in joint ventures with Sinopec. Finally, also in the interpretation of the joint venture network, one should be aware of the context of the different corporations. For example, the close relation[10] of Brazilian Braskem with state-controlled oil producer Petrobras means there is less incentive to set up joint ventures with other oil companies.

The two diagrams in Figure 3 do not show social ties between corporations, but rather spatial ties on the basis of shared locations in global subsidiary networks in 2017. The left side of the diagram is based on the absolute number of *meeting points* or *co-locations*, while the right side of the diagram is based on a relative score in which the lowest number of unique locations of the two subsidiary networks is the denominator. What immediately stands out is that every corporation was connected to every other corporation through at least one shared location. The most important shared location is Houston, the only place that is part of all fourteen subsidiary networks. This self-proclaimed *energy capital of the world* (Blevins 2014) seems to be equally important as the *petrochemical capital of the world*, connecting the company networks of Western and non-Western companies.

In Figure 3 (left side) we notice that North American and European corporations are at the center of the network, relatively close to each other, which means they shared a substantial number of locations. The strongest tie is between BASF and DowDuPont (122 shared locations), followed by DowDuPont-Air Liquide (109 locations) and

[9] See https:basf.com/global/en/who-we-are/history/130-years-of-basf-in-china.html for details on BASF's Chinese operations.

[10] Petrobras owns 36.1 percent of Braskem's outstanding shares and 47.0 percent of its voting shares (http://braskem.com.br/RI/ownership-structure).

Table 2

Summary of Results of the Multiscalar Corporate Network Analysis through the Concepts of Contextuality, Path Dependence, and Contingency

	Contextuality	Path Dependence	Contingency
Corporate board networks	Companies have different ownership structures, and varying international ambitions may lead to more inward-or outward-looking corporate boards.	Resilient Western elite networks remain centered on the North Atlantic petrochemical heartland, while emerging economy elites remain isolated.	Some corporate links deviate from the general pattern of isolation of emerging economy elite networks (e.g., Braskem-ExxonMobil).
Joint venture networks	Different company strategies (e.g., vertical integration versus specialization) and close ties with (state-controlled) oil companies influence different joint venture networks.	Specific business histories (e.g., BASF in China) and geopolitical relationships (e.g., between the US and Saudi Arabia) form foundations for joint venture creation.	Fixed life span and limited scope of operations of joint ventures allows for strategic collaborations between Western and emerging economy corporations, to adapt to economic change and uncertainty.
Spatial interlock networks	Different corporate ambitions (e.g., regional versus global leadership) lead to different geographic networks and locations of activities. Importance of *gateway cities* and THOFCS in reorienting subsidiary networks.	Subsidiary networks of Western companies form the backbone of the global spatial organization of the industry to which all new corporations connect to some extent. Continuing importance of established Western petrochemical power centers.	Some Asian and emerging economy corporations develop detached regional subsidiary networks and take a peripheral position in the global spatial organization (e.g., Sinopec). Emergence of new strategic power centers in Asia and South America.

BASF-Air Liquide (104 locations). This triad is surrounded by the three other Western corporations, the three Asian post–World War II entrants, and the five emerging economies corporations positioned the furthest from the center. This observation could easily lead to the conclusion that non-Western corporations, and particularly those from emerging economies, are rather weakly integrated in the global petrochemical network. However, this network is based on the absolute number of interlocks and is severely distorted by the variation in the number of subsidiaries, and hence in the number of unique locations, in the different corporate networks. The spatially most diverse network, DowDuPont, had a link to 421 locations, while PTT Global Chemical was only present in 10 locations. On average, the European and North American corporations had far more locations in their network (247) than the Asian post–World War II entrants (109) and the emerging economies corporations (35).

The diagram based on relative strength of spatial interlocks (Figure 3, right side) provides a different view. Again, it shows that Air Liquide, BASF, and DowDuPont are central to the network. However, PTT Global Chemical and Braskem also have a central position. This means that a lot of the (relatively few) locations in their company networks were shared with other corporate networks. For example, of the ten locations in PTT Global Chemical's corporate network, seven were also part of Air Liquide's and BASF's networks. On the other side of the spectrum, Sinopec and Formosa Plastics remain very poorly integrated and peripheral in the network diagram. For example, of the seventy-one locations in Sinopec's network, on average only 18 percent were shared with other corporations. This illustrates China's aim of self-sufficiency going together with a focus on consolidating a national (or regional) corporate network (Tobin 2019).

We can conclude there is substantial integration between subsidiary networks with very different sociospatial histories. This global constellation demonstrates a high degree of path dependence, with the subsidiary networks of Western companies still forming the backbone to which the networks of post–World War II Asian entrants and emerging economies corporations connect (illustrated by the central positioning of BASF, Air Liquide, DowDuPont, and LyondellBasell in the right diagram). At the same time, the peripheral position of some corporations in the spatial interlock network

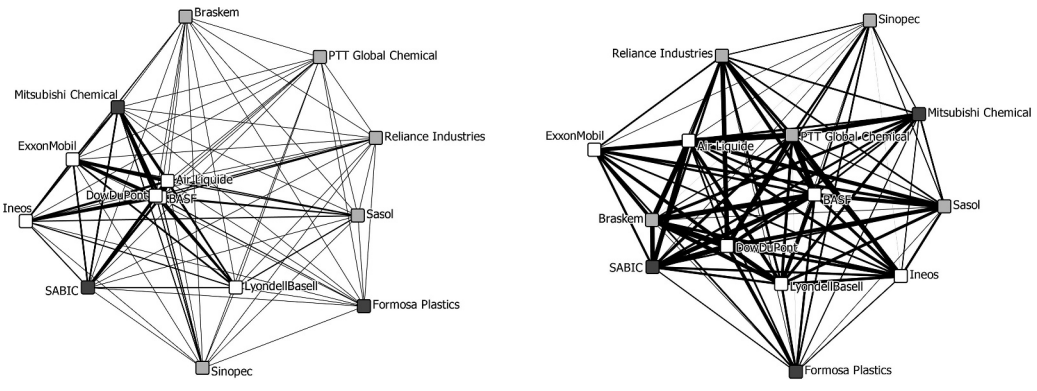

Figure 3. Spatial interlock network based on absolute number of overlapping locations (left side) and relative number (right side).
Note: White squares: companies based in Europe and the US; dark grey squares: post–World War II Asian entrants; light grey squares: companies from emerging economies. Tie width represents the degree of spatial interlocking, and metric multidimensional scaling was applied.

means they are following different spatial logics, confirming the contingent character of subsidiary networks. Finally, different corporate ambitions, for example, regional or global leadership, require us to take context into account when interpreting this network from the perspective of power structures (Table 2).

While it is clear from both diagrams that subsidiary networks connect to each other, it is not clear *where* they connect. We define *meeting points* as the locations where corporations headquartered in the traditional North Atlantic core were present together with corporations from other parts of the world. These meeting points could be strategic places in the next stage of the petrochemical era, given the growth of non-Western corporations, though unpredictable events—such as COVID-19 and the crude oil crash in 2020—can always steer the global spatial organization of the industry in new directions. In Figure 4 we have mapped these meeting points, and we have highlighted the most important ones. The grey nodes represent all meeting points, places where at least one Western and one non-Western corporation is present. These nodes are concentrated in the eastern part of the US, Western Europe, and along the Asian Pacific coast. Apart from these three areas we find meeting points scattered across the globe, though with a clearly lower presence in South America, Africa, and Australia. Our map shows that the spatial organizational hierarchy of the petrochemical industry is quite resilient, with cities in the US and northwestern Europe still forming the backbone. However, we also identified new meeting points or strategic hubs, particularly in Asia, pointing to a slow geographic shift of strategic power, following the geographic shift of production and the growth of non-Western companies. It also confirms the idea of a multipolar world order and the end of the American hegemony (Amin 2013).

The star-shaped nodes in Figure 4 represent *top meeting points*, places where at least half of the Western companies (three out of six) and half of the non-Western companies (four out of eight) of our sample were present. There were exactly ten of these locations, half of them located in the old petrochemical heartland of Western Europe and the US, and half of them located in other parts of the world (mainly Asia). This

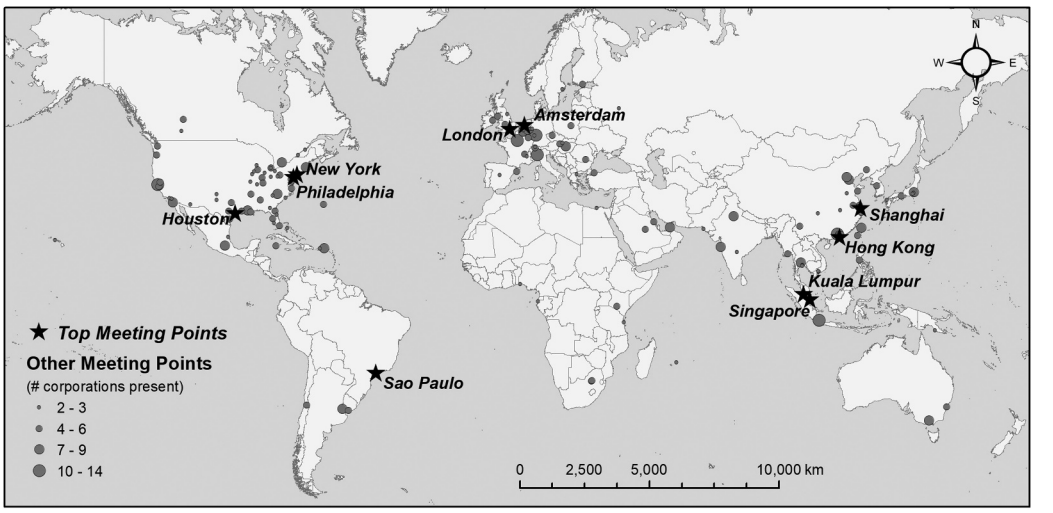

Figure 4. Location of *meeting points* where the subsidiary networks of American and European corporations integrate with those of Asian and emerging economies corporations.

again supports the view of a relatively resilient structure of traditional Western petrochemical power centers, combined with a significant move to new strategic centers elsewhere. Of the ten top meeting points, nine are so-called Alpha global cities, the primary nodes in the global economic network as defined by the Globalization and World Cities Research Network (GaWC) in 2018 (https://www.lboro.ac.uk/gawc/world2018t.html). Philadelphia is the only beta city, meaning it is of lower global importance. Its significance mainly depends on having the city of Wilmington (Delaware) in its urban agglomeration, home to the headquarters of DuPont and a typical place where companies register an office due to its desirable corporate taxes and law, permitting operations across the whole US. Despite this large overlap, some important global cities are clearly missing, such as Paris, Tokyo, and Dubai, while lower-ranked global cities, such as Amsterdam and Houston, take a prominent place. These two cities in particular can be understood through the perspective of *globalizing cities*, cities whose urban positionality differs from one network to another (Krätke 2014). They are key points in the organizational hierarchy of the petrochemical industry, which is partly detached from the assumed structure of *global cities*. This organizational hierarchy is less driven by command and control motivations, but rather is the result of historic path dependence, contextuality (e.g., resource availability and market access), and contingency (e.g., geopolitics and firm-based locational strategies) (Sigler and Martinus 2016). Some of these cities also take up a role as *gateway cities* or focal points in *regionalizations* of the petrochemical industry (Brown et al. 2010). Singapore, for example, has been shown to be a *gateway city* in upstream oil and gas global production networks, and has a long history as a refinery and transport and logistics hub for the petrochemical industry (Breul and Diez 2018). Finally, in the territorial configuration of the global petrochemical industry, we identify the reorientation from supply- or demand-side advantages to purely financial considerations, leading to global firm networks mimicking geographies of taxation (Sigler et al. 2020). No less than five out of ten top meeting points are often listed as THOFCs: Hong Kong, Singapore, Kuala Lumpur, Amsterdam, and Wilmington (Philadelphia). Other notorious places, like Bermuda and the British Virgin Islands, can be easily spotted on the petrochemical map. This represents a network development that is contextual, following the geographies of taxation, yet contingent on unpredictable events such as changes in regulation.

Discussion

In this article we have brought together literatures on corporate elite networks and world city networks, and combined their methodologies in an innovative, relational analysis of the global petrochemical industry. We have worked with a judgment sample of companies with the aim of gaining insights into the social and spatial organization of this complex industry. We have found a combination of integration and isolation in the industry's corporate board, joint venture, and spatial interlock networks. In combination with longitudinal industry data, business histories of the petrochemical industry (Chandler 2009), and recent debates about the shift toward a multipolar global world with competing corporate elites and places (Amin 2013; Heemskerk and Takes 2016), we have interpreted our findings as a combination of resilience and change, or path dependence and contingency, in patterns of power and collaboration.

In line with transnational capitalist class studies and the idea of an *Atlantic ruling class* (van der Pijl 1984), we have found a very resilient and integrated North Atlantic elite network, with all Asian and emerging economy companies being isolated.

However, we argue for a nuanced interpretation of these findings, for path dependence and differences in corporations' global ambitions are also important explanatory factors. The global joint venture network was much more integrated, with emerging economy corporations being important partners for European and North American companies, and with a significant similarity in external joint venture partners leading to an integrated global company system that includes almost every company in our sample. Finally, the global spatial interlock network was relatively integrated, with subsidiary networks overlapping to a significant degree, pointing to the relevance of spatial proximity and agglomeration effects in this industry. The global spatial interlock network demonstrates a high degree of path dependence, with the networks of Western companies forming a resilient backbone, though some corporations that do not fit in the multinational logic have more detached regional networks. Geographically, the petrochemical power hubs in Europe and the US have retained their power but have been joined by emerging strategic centers predominantly along the Asian Pacific coast, confirming the shift toward a multipolar global order.

Our study has some limitations. First, the small judgment sample of fourteen global petrochemical companies and the cross-sectional character of our data analysis requires us to be cautious in our statements about the petrochemical industry, let alone the global economy (e.g., the existence of a transnational capitalist class). However, the fourteen corporations were carefully selected based on being part of the top ten global companies or on being located in emerging economies, to get an idea of what the further growth of emerging economy corporations might mean for the industry's social and spatial organization. Second, data were collected from verified databases, manually checked and expanded, but still contain some flaws. For example, the quality of Orbis data is variable, and information on directors' affiliations and joint ventures is more accessible and reliable for European and American corporations. Third, only specific forms of corporate interlocks were explored: corporate board interlocks, joint venture interlocks, and spatial interlocks. Other ways of corporate interlocking (such as contracts—see de Graaff 2011) were not examined. Fourth, the spatial corporate interlock analysis includes all subsidiaries and does not take into account where most value is added or which places are most important for a specific company. We would need more in-depth qualitative research and more comprehensive subsidiary data to go beyond a rough estimate of the spatial range of a company's activities and make firmer conclusions about the strategic power of particular cities. Finally, an important limitation of our analytical framework is the focus on the network structure, only revealing the social and spatial *conduits* of economic agency or power (Grabher 2006; Glückler 2007; Sunley 2008). While we argue that our analytical framework advances an understanding of structural power relations, we admit it falls short of conceptualizing or analyzing how power and agency are effectuated through these networks.

Our present analysis has captured a snapshot in time of rapidly changing networks but nonetheless reveals the legacies of continuity—the established power networks of dominant Western firms—together with the seeds for transformative change—the extent of emerging network structures moving in new directions. While corporate elite networks in emerging economies remain isolated from the established elite core, corporations in emerging economies have integrated with Western companies through joint ventures and spatial interlocks in petrochemical hub cities. This finding is in line with de Graaff's (2011) conclusions on recent evolutions in the oil industry. She noted a dual development of state-controlled oil companies' remarkable expansion and simultaneous integration. The implication is that while traditional Western

multinationals might have lost power in terms of market share, and emerging economy corporations like Sinopec or PTT Global Chemical might have gained power, they have also become increasingly interdependent. As de Graaff (2011, 279) argues, "the growing transnational dimension might be the most important and fundamental aspect of the recent period," with the distribution of power becoming "increasingly diffused." On the one hand, our analysis of changing global petrochemical elite networks points to a new balance of power between well-established Western multinationals and rapidly growing challengers from emerging economies. On the other hand, our analysis of integration in a diversified playing field underscores the importance of interdependence in a global economy. The shift to a multipolar—but also more interdependent—global economy may be even more acute in the aftermath of the COVID-19 pandemic, with intensifying geopolitical rifts between the US and China, and international pressure to address climate change. Through applying a multiscalar corporate network analysis to investigate the complex dynamics of isolation and integration in the petrochemical industry, we hope that our study inspires further in-depth mapping of similar shifting power balances in the global economy.

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