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The duality of firms and directors in board interlock networks: A relational event modeling approach

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ABSTRACT

The long tradition of scholarly work on corporate interlocks has left us with competing theoretical frameworks on the causes of interlock networks. Board interlocks are studied either as means to overcome the resource dependence of corporations or as a group cohesion mechanism of business elites. This contrast is due to an empirical divide of the literature where either the firms *or* the individuals are considered as decision-making bodies. In systematically ignoring the agency of the other group of actors, these literatures suffer from both theoretical and empirical biases in understanding the drivers of new interlocks. In this paper, we employ a relational event modeling technique that allows us to overcome this problem. The analysis of board appointments in Denmark demonstrates how in fact both personal and corporate considerations simultaneously drive the evolution of the corporate networks. The study of the duality of actors is essential for understanding the causes and consequences of corporate networks across time and space.

1. Introduction

Interlocking directorates, where corporate directors hold positions on the boards of more than one firm, have been a focus of interest in a wide range of scholarly fields (Mizruchi, 1996) as the social structure underpinning corporate elite cohesion (Chu and Davis, 2016; Heemskerk and Takes, 2016), as a set of strategies for firms to overcome resource dependencies (Hillman et al., 2009), as an infrastructure for the diffusion of corporate governance practices (Shropshire, 2010), organizational learning (Tuschke et al., 2014), and as part of the institutional ensemble of particular varieties of capitalism (Cárdenas, 2012; van Veen and Kratzer, 2011). Decades of research into interlocking directorates have, however, left us with a broad range of theoretical frameworks explaining why board interlocks exist as they do. While we know a considerable amount about the consequences of board interlock networks, which mechanisms drive these networks' dynamics remains both theoretically and empirically contested.

The literature on board interlocks is traditionally divided into two broad groups of studies based on their actor orientation: either focused on organizations or individuals (Lamb and Roundy, 2016). This theoretical opposition between organizational and individual perspectives has long been recognized in the literature (Koenig et al., 1979; Scott, 1991) and is not problematic per se. Problems do arise, however, if we try to understand the formation and evolution of interlocks exclusively from *either* an organizational or an individual perspective. The dominant theoretical opposition is perpetuated by the methodological challenges of social network analysis studies. Most empirical papers on board interlocks are restricted to studies of only one group of actors, either firms or individuals depending on their theoretical position. Empirical literature that takes an interorganizational perspective studies firm-by-firm networks in which the nodes are corporations that are connected by shared directors. Conversely, corporate elite literature focuses on networks of individuals, in which directors are connected if they are affiliated with the same boards. These firm-by-firm and person-by-person networks are called one-mode networks and each of them contains only *one* type of actor, either firms or individuals (Robins and Alexander, 2004). In reality, these one-mode networks are projections of the underlying two-mode affiliation network that connects firms *and* individuals. The 'duality of persons and groups' (Breiger, 1974) is what distinguishes two-mode networks from one-mode networks, and is something we clearly see in the case of board interlocks. However, even though the duality of interlock networks has been discussed for decades, the literature still fails to recognize this duality not only at a theoretical level but also at an empirical level and to include both corporate boards and individual directors in its analysis.

We will argue that the main obstacle that stands in the way of a proper understanding of what drives board interlock formation is the consistent failure to comprehensively study board interlocks as a two-

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mode network of persons and firms. Our concerns are not new; many scholars before us have pointed to the limitations of studying board interlocks at the one-mode firm-by-firm level (e.g. Piepenbrink and Gaur, 2013; Robins and Alexander, 2004). And one-mode projections of two-mode networks also lead to methodological biases such as overestimation of network clustering (e.g. Borgatti and Everett, 1997; Faust, 1997; Latapy et al., 2008; Vernet et al., 2014). Yet only a handful of studies actually apply a two-mode approach to studying board interlock networks (Koskinen and Edling, 2012; Robins and Alexander, 2004). These few studies primarily develop and demonstrate new two-mode network modeling techniques or measurements; their engagement with and contribution to the theoretical debate remains limited. Therefore, the existing literature on causes of board interlocks leaves us with a theoretical-methodological conundrum that is difficult to disentangle. This deadlock combination leads to systemic biases such as ignoring the agency of directors in interfirm interlock ties. Analyzing only one group of actors, we may conclude that a specific social mechanism resulted in the formation of ties in the network. However, looking at another group of actors within the same network, we may conclude that a completely different social mechanism leads to the formation of ties in it. If we would consider both groups of actors, we would be able to observe both social mechanisms that drove the network formation. In sum, described theoretical and methodological problems inhibit our ability to answer the question of how firm-level and individual-level considerations contribute to board interlock formation.

In what follows we revisit this foundational discussion in the field of board interlock research and develop an original theoretical and empirical approach to assessing how organizations' and individuals' interests drive board interlock dynamics. We go beyond previous works, which have studied board interlock dynamics by comparing different static snapshots of a one-mode firm-by-firm network over time. Instead, we shift our attention to the source of tie formation: board appointments and their embeddedness in two-mode network microstructures. We test the presence of firm-related and individual-related drivers of the board interlock networks using the Relational Event Modeling (REM) framework (Butts, 2008). As an empirical setting, we have created an original high-quality dataset on 14,893 board appointments of 10,377 directors to the 3,304 largest corporations in Denmark over twenty years (1994–2014).

This paper makes a number of contributions to board interlock and network analysis research. On a theoretical level, we develop a novel perspective for understanding board interlock dynamics as outcomes of co-existing interests of firms and directors. This allows us to move beyond the theoretical and methodological deadlock between the literature oriented exclusively around organizations or individuals. In recognition of the duality of groups and persons, our results show how individual- and firm-level forces both play a role at the same time. Methodologically, this research is the first to apply relational event modeling to understanding the evolution of board appointments and the resulting board interlock network. The two-mode nature of the model makes it possible to handle the dynamics of board appointments while taking into account the duality of interests of individuals and corporations.

The paper is structured as follows. Sections 2 and 3 review the problem of the duality of actors in board interlock networks. In Section 4 we build hypotheses. Section 5 presents an empirical case and the methodological approach. Section 6 describes the results and in Section 7 we discuss the findings and the potential broader applications of the presented approach.

2. The persistent duality of individuals and firms in board interlock networks

2.1. Organizations vs individuals

What drives board interlock formation? Many decades of research have left us with dispersed literature and piecemeal answers to this important question. The main dividing line in the literature is a consequence of what Breiger called 'the duality of persons and groups' (Breiger, 1974). While one part of the literature is mainly interested in the organization's perspective, another group emphasizes that of the individual. In the 'organization's perspective' camp, the influential resource dependence theory argues that firms create interlocks to access resources such as information or capital and to acquire access to influential actors such as banks and financial institutions (Burt, 1983; Mizruchi and Stearns, 1988). Shared directors play a key role in obtaining these resources because they provide access to external environments (Hillman et al., 2000) and allow the firms to improve monitoring and decrease environmental uncertainty (Carpenter and Westphal, 2001). Firms can strategically form interlock ties with specific actors because these ties can serve as a mechanism to manage dependence on particular resources. For example, in case of knowledge dependence, when there is a need to pursue new technologies, firms will tend to form interlocks with firms that are active in defending their intellectual property and whose core technologies are aligned with the firm's global trajectory (Howard et al., 2017). Furthermore, interlocks have reputation-seeking and signaling functions, demonstrating to others the firm's unique position in its environment (Connelly et al., 2011).

Individual-level theories, on the other hand, conceptualize board interlocks as a phenomenon caused by the actions of individuals as parts of broader social groups. For example, interlocking directorates have been widely conceptualized as an intraclass phenomenon that is instrumental for the social cohesion of the corporate elite (Domhoff, 1967; Useem, 1984). From this perspective, board interlocks are created to sustain the class identity of members of the capitalist class, to transmit social norms, and to create opportunities for political action (Carroll et al., 2010; Sklair, 2001). More individualistic explanations, such as career advancement theories, argue that directors join multiple boards to obtain better financial remuneration and prestige which will help to improve their career prospects (Westphal and Stern, 2006). Concurrent affiliations also serve to signal a director's high connectivity, which leads to higher social capital and gives access to diverse actors (Johnson et al., 2011).

These diverging theoretical perspectives have triggered an ongoing discussion on the importance of firms versus individuals in driving board interlock dynamics, which started in the 1970s as an exchange between Allen and Zeitlin (Allen, 1974; Zeitlin, 1976). Allen argues that corporate interlocks are a function of organizational resource dependence and Zeitlin was responding that interlocks are usually created for sustaining capitalist class cohesion. This debate remained unresolved for some time because it was hardly possible to test empirically the prominence of firm or individual-related social forces leading to the formation of interlock ties. At the beginning of the 1980s, a group of sociologists presented an original way of testing the prominence of these social forces that promised to resolve the debate (Koenig et al., 1979; Ornstein, 1982; Palmer, 1983). This literature tested the relevance of interorganizational or class drivers by looking at the reconstruction of broken ties in interlock networks. The argument of the broken ties literature is as follows: if interlocks serve as channels for essential resources for organizations, then when these ties spontaneously disappear as a result of the death or voluntary retirement of a director, the interlocks need to be reconstructed. But if interlocks are predominantly based on individual relationships and are the result of class cohesion mechanisms, then this cannot be done swiftly. The outcomes of these studies demonstrate a low level of tie reconstruction, leading to the conclusion that intraclass relations provide a more accurate explanation of the causes of interlocks.

However, if the majority of interlocks are driven by class cohesion, it does not mean that inter-organizational resource dependence does not play a role at all. Some studies already hinted that both interorganizational and class perspectives are significant for tie

reconstruction and both should be taken into account (Ornstein, 1982). Even though the broken ties approach was a brilliant attempt to resolve the old debate, it was clear that it is hardly possible to distinguish the relative importance of these diverging social forces. These theoretical explanations of board interlock ties are rather complementary than contradictory (Mizruchi, 1996).

Although the broken ties literature gave evidence that elite mechanisms are more essential for forming new interlocks and the consequent literature showed that both organizational and elite forces might play a role at the same time, the majority of literature on interlocks today are taking inter-organizational perspective. The resource dependence perspective remains highly dominant in the literature (Hillman et al., 2009), in part due to a shift in what are considered to be legitimate research interests. From the late 1990s onward, organizations have received more scholarly interest than capitalist classes (Fennema and Heemskerk, 2018).

2.2. The two-mode nature of board interlock networks

The persistent opposition between individual and organizational perspectives is both theoretically and methodologically related to the duality of persons and firms in board interlock networks. While interlocks are typically studied as a set of network relations between firms, this reflects only one side of the underlying affiliation network where people are related to firms. Networks with actors of different types of nodes are called two-mode networks. Ties in these networks are possible only between different modes, not within one mode. Fig. 1 gives a visual representation of the difference between one-mode and two-mode networks. The left-hand side shows a two-mode network in which firms A and B and individuals X and Y are connected by board affiliations. The right-hand side of the figure shows two one-mode projections of this affiliation network. The set of positions connects firms A and B (namely through their shared directors X and Y) and similarly connects directors X and Y. Ties in these networks are weighted and have a weight of two, which means that A and B have two shared directors and X and Y work at two shared boards.

Taken together, the literature suggests that both individuals and firms play a role during the formation of new board interlocks (Mizruchi, 1996). Nevertheless, most studies consider firm-by-firm interlock networks (e.g. Buch-Hansen and Henriksen, 2019; Withers et al., 2018), while a smaller body of work investigates person-by-person networks (e.g. Larsen and Ellersgaard, 2017). In recognition of the theoretical and empirical limitations of studying one-mode projections, some authors study both firm-by-firm and person-by-person networks (Carroll et al., 2010; Heemskerk, 2007). This allows them to describe the relationships within each projection of an interlock network in a detailed way but does not go as far as considering the structure of the two-mode network itself. Likewise, sometimes papers focus on one group of actors but expand their results to another group.

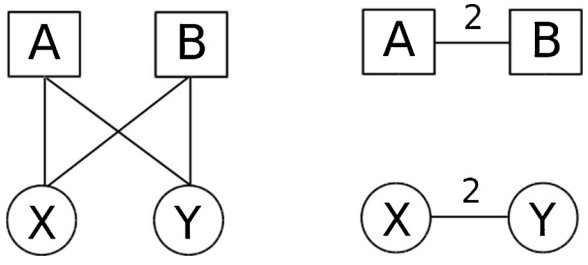


Fig. 1. Two-mode network of board interlocks (left) and its one-mode firm-by-firm and individual-by-individual projections (right). Squares are firms (A and B), circles are individuals (X and Y). In two-mode network, ties are affiliations between firms and individuals. One-mode networks are weighted, each tie has a weight 2 which is the number of shared directors or the number of common boards.

For example, the broken ties literature shows that intraclass causes are more important for the creation of interlocks, but these results were obtained using data about relationships between firms, not individuals. Problems emerge when one considers only one side of the network, ignoring another mode. This can lead to serious biases in the interpretation of the social processes that take place in networks. We demonstrate an example of such bias in the next section.

3. Network building strategies of firms and individuals in board interlock networks

3.1. Expansion and reinforcement strategies in board interlock networks

In board interlock networks, as in any other social networks, actors can use their connections to obtain higher social capital (Burt, 2005; Bourdieu, 1986; Coleman, 1988). Social capital is a possible advantage created by the position of an actor in networks that can be further used for action. For example, by creating interlock ties with specific actors in the network, firms obtain valuable information and resources (Salancik and Pfeffer, 1978). By forming these potentially resourceful ties, firms are able to make more informed decisions and behave in a coordinated way. Actors in board interlock networks can have two diverse strategies to establish their social environment and to obtain social capital: network *expansion* and network *reinforcement*. We conceptualize these strategies below and build our hypotheses based on these strategies.

Many social and organizational networks are small-world networks (Kogut and Mitchel, 2012): actors in these networks tend to create dense clusters of relationships, separated by structural holes (Burt, 2004). Actors are densely inter-connected inside their own cluster but weakly connected across different clusters. They can strategically create ties in order to connect to new actors, to obtain new information and resources by expanding their network environment. Using this strategy is challenging because actors need to extend their own social circles and to be open to new information, actors, and environments. But as soon as actors are able to expand their already existing social circles, new ties may bring them a vast amount of opportunities such as access to diverse information and resources. This strategy can be related to establishing weak ties: actors seek diverse information and connect with actors that are different from their established social environment (Granovetter, 1973). For the case of board interlock networks, we call this strategy to form ties in board interlock networks the network *expansion strategy*.

The second strategy to form ties is to reinforce already existing ties by seeking closure (Coleman, 1988; Burt, 2005). In this case, actors strengthen ties that already exist within their closest social environment: they create ties with actors that belong to their social circle. For example, an actor might choose to form a tie with another actor that is completely different based on its characteristics and/or is located further away in the network. But instead, this actor prefers to form a tie that is already very close, i.e. actor's other partners are already connected with this node. This tie does not create a completely new type of relationship with a distant node, it reinforces already existing connections within the closest network environment. These types of ties often do not bring new resources, information or diversity. But they bring social norm reinforcement and increased trust levels in networks. We call this strategy of actors to create ties in board interlock networks *reinforcement strategy*.

3.2. Diverse strategies of actors in board interlock networks

Network expansion and reinforcement strategies are common ways of building ties and accessing social capital in social and organizational networks. We will demonstrate both strategies at work using the example of board interlock networks that are our case study in this paper. To show how the interpretation of these strategies differs depending on the actor selection (taking organizational or individual perspectives), we give two examples. In the first example, we take one-mode firm-by-

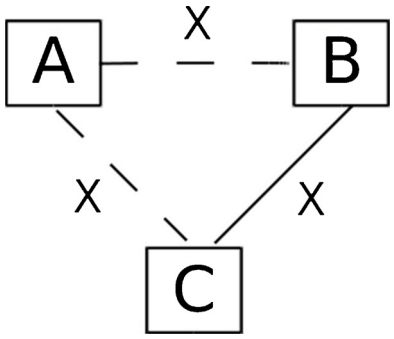


Fig. 2. One-mode firm-by-firm network, dotted lines are potential ties, non-dotted lines are already existing ties. Network reinforcement strategy is demonstrated. Firms B and C share a director X; by creating interlocks with firm A, firms reinforce connections with each other.

firm network and in the second example we look at the same network but from the point of view of individuals, or taking one-mode individual-by-individual network. Our aim is to show that when we study one-mode projections, we observe opposing network formation mechanisms and this can result in biased conclusions about the underlying two-mode network structure.

In our first example, we start with the one-mode network of firms. A typical example of a network reinforcement strategy of firms would be a network microstructure that can be potentially closed in a fully connected triad (Fig. 2). In this network microstructure, we have three firms: A, B, and C. Firms B and C already have an interlock tie with each other (they share director X). There is a firm A in their closest social neighborhood. If any of the firms (either B or C) will form an interlock tie with firm A, another one is also likely to create an interlock with A. For example, if A and B will form an interlock tie with each other, C will also create an interlock with A.

This tendency frequently occurs in social and organizational networks: non-transitive triads will tend to close and become transitive. The transitivity of triads is a situation when “a friend of my friend is also my friend”. If we think about firms and their organizational behavior, the formation of transitive triads of interlock ties is very likely. Firms A, B, and C are likely to become fully connected because they already know each other, i.e. they share the same director X. If this non-transitive triad will become a transitive triad (when A, B, and C are all connected), the potential tie of A with B or A with C will be a reinforcement tie. We clearly observe a reinforcement strategy that led to the formation of ties in this one-mode network microstructure. This type of behavior might be beneficial for firms because they are in a familiar network environment with other firms and sharing the same directors allows them to behave strategically as a group.

Looking at firm behavior and firm-by-firm networks is a typical way of investigating board interlock networks. But it is known that interlocks are not the result of exclusively firm-related behavior. As Mizruchi noted in his seminal paper, “interlocks occur between organizations, but they are created by individuals” (Mizruchi, 1996: 277). We can look at the same network microstructure, presented in Fig. 2, from the point of view of individuals who sit on boards of the named firms A, B, and C. In other words, we look now at the one-mode individual-by-individual network (see Fig. 3).

Since there is an already existing board interlock tie between firms B and C, it means that they share at least one individual, namely the director X. When X participates in board meetings of firm C, it means that X is connected with other directors of firm C: Z1, Z2, Z3, etc. For visualization reasons, we denominate this group of directors as ‘Z’ in Fig. 2. At the same time, X is also on board of firm B, meaning that X knows directors ‘Y’. As we can see, individual X is already well-connected within this network microstructure. If X will join the board of firm A, this individual will create interlock ties between firms A and B

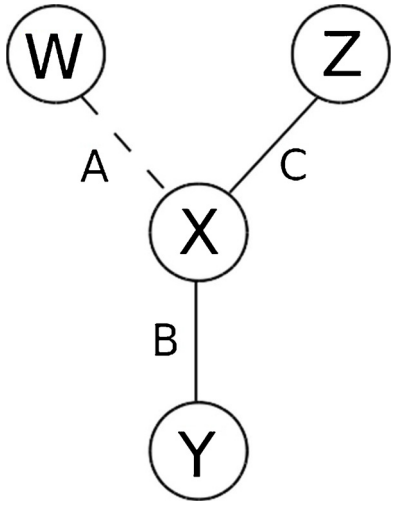


Fig. 3. One-mode individual-by-individual network, dotted lines are potential ties, non-dotted lines are already existing ties. Network expansion strategy is demonstrated. Director X is on board of firms B and C and is connected with directors of B (Y) and directors of C (Z). Director X expands its network ties by connecting with directors sitting on board of firm A (W).

and between firms A and C, as we have also seen in Fig. 2. In this case, X will be additionally introduced to all board members of A: W1, W2, W3, or ‘W’. We see that X is joining more and more boards and besides forming new interlock ties between firms, it also expands its own social network by meeting new people. As a result of this network formation process, X is in contact with board members of all three firms: A, B, and C. For director X, joining the board of firm A is a step towards further network expansion because X does not know board members of A yet. Joining the board of firm A will bring X diverse social ties and novel information from a new group of people. Network expansion mechanism is in the core of X's behavior.

What do these examples show us? They demonstrate that it is possible to look at board interlock networks from different perspectives: from either firm or individual viewpoint. This is not surprising and this is actually what the majority of the literature on board interlocks is doing. It seems like an obvious way of analyzing these networks when, depending on the primary focus of interest, one investigates either firm-by-firm or individual-by-individual relationships.

But there is a potential pitfall here. When we study the two one-mode projections of the same two-mode network, we observe opposing network mechanisms. In the two mentioned examples, we presented the same network microstructure but from different perspectives. Taking only one perspective (firm or individual), one can conclude that there was a specific mechanism that led to the formation of this network microstructure. For example, if we would look only at firms (Fig. 2), we would conclude that the network was based on network reinforcement interests of firms. When we look at the same case from the point of view of individuals (Fig. 3), we saw that the same ties might have also resulted from network expansion interests of individuals.

What is specific about board interlock networks is that they are two-mode networks, i.e. networks that consist of two different groups of actors: firms and individuals. To make it more clear, we present the third figure (Fig. 4) which is the two-mode representation of both firm-by-firm (Fig. 2) and individual-by-individual (Fig. 3) network microstructures that we described above. In Fig. 4, we have the same three firms A, B, and C. Each of them has boards that we denoted before as W, Y, Z. Director X, the main actor that we are interested in, already has positions at firms B and C. X has the potential to join the board of firm A. If this tie between A and X forms, it will be the result of network reinforcement (firms create interlocks with each other) and the result of network expansion (X meets new directors) strategies. We see that the

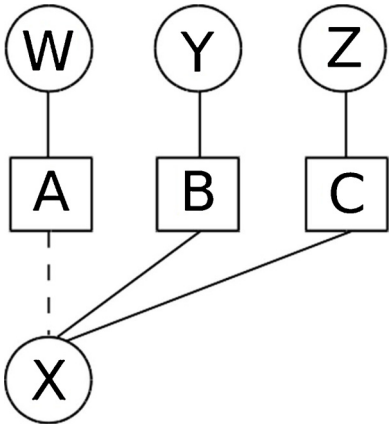


Fig. 4. Two-mode firm-by-individual network, dotted lines are potential ties, non-dotted lines are already existing ties. Squares are firms, circles are individuals. This figure summarizes both Figs. 2 and 3 as a two-mode network. Firms A, B, and C have boards W, Y, and Z. There is a potential tie between individual X and firm A.

interests of firms and individuals can co-exist in the same network microstructure and when we analyze firms and individuals separately (as we did at Fig. 2 and Fig. 3), we do not see that ties can be driven by both strategies at the same time: reinforcement and expansion.

This duality of actors and their interests is not surprising for social and organizational networks (Breiger, 1974). The problem is that we still do not know how to deal with this duality. The common solution in the literature on board interlock networks is choosing one type of actors and analyzing them, ignoring another group of actors. As we have seen from the examples, doing so we omit the interests and strategies of another group of actors while it is clear that they also played a significant role in the formation of these ties.

It is impossible to separate causes of ties in board interlock networks and to mark a clear line between the interests of firms and individuals. The broken ties literature was intended to do so by separating firm and individual causes of ties but it inevitably failed. In the two examples above, we see that both reinforcement and expansion strategies of firms and individuals can co-exist within the same network microstructure if we look at its two-mode nature. Conversely, if we take any of the one-mode perspectives, we do not observe all the potential drivers of social ties in a complete social system, with all actors included. These diverse strategies of firms and individuals do not contradict each other, they can take place within the same network. Because we observe different mechanisms in the two one-mode projections, theorizing interlock formation at a one-mode level must lead to opposition and debate. Therefore, we should not ignore the agency of both groups of actors and need to theorize board interlock networks at the two-mode level.

3.3. Two-mode board interlock networks as a case for methodological developments

Two-mode network analysis is a logical approach to the study of board interlocks as we know that one-mode projections of two-mode networks lead to biases in understanding the network structure (Piepenbrink and Gaur, 2013). Nevertheless, there are only a handful of papers that apply a two-mode modeling approach to board interlock networks. For example, Robins and Alexander (2004) note that we need a detailed investigation of the question of whether it is intercorporate alliances or interpersonal networking that cause multiple interlocks, a typical example of a contradicting duality of agents. Multiple interlocks are cases when two directors are affiliated with the same two boards; these interlock structures are problematic for analysis because they might be simultaneously driven by the interests of firms and individuals. However, the methodology presented in the paper is not able to clarify the relative strength of the dual interests in board interlock networks. Another paper using a two-mode network approach studies the peer referral mechanism, the practice where board members recommend others they already know to their current boards (Koskinen and Edling, 2012). Even though the two-mode structure of board interlock networks is discussed in detail, the results of this paper are interpreted from the perspective of individual directors, leaving corporate interests unaddressed. To be fair, the main objective of these studies is to make methodological advancements in the field of two-mode network analysis. Board interlocks are used as a well-studied typical example of affiliation networks, but the theoretical implications of related findings remain underdeveloped. Also, the separation of the literature into distinct groups that prefer to study either organizations or individuals makes it difficult for these two-mode studies to make a theoretical contribution.

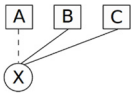
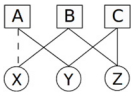
In this paper, we stress that we should not only analyze board interlocks as two-mode networks but we should also think about them as social systems characterized by the duality of actors and their interests. We demonstrate our approach using data about Danish corporate appointments over twenty years and predict the formation of ties in the dynamic two-mode network. In the next section, we describe main organizational and individual-level theories explaining board interlock ties and build our hypotheses based on them.

4. Hypotheses

For building hypotheses, we focus on two network microstructures that drive the evolution of two-mode interlock networks: the popularity of directors and six-cycles. The visualization of these network patterns are presented in Table 1.

The first row of Table 1 illustrates the two-mode network microstructure that we relate to the popularity of directors. In board interlock papers, the influence of a director's position is usually measured by director popularity, or the number of board positions. In this network microstructure, director X is a popular director because this person was previously appointed to the boards of firms B and C. Because of this

Table 1
Illustration of hypotheses and tested network microstructures.

Hypotheses	Network microstructure	Network illustration	Mechanism in firm-by-firm network	Mechanism in individual-by-individual network
H1	Popularity of directors		Reinforcement	Expansion
H2	Six-cycles		Reinforcement	Reinforcement

Note: Squares are firms, circles are individuals. Dotted ties are predicted board affiliations, non-dotted ties are already existing board affiliations.

central position, director X is of interest to firm A. We already presented this network microstructure above (see Fig. 4) and concluded that if we make a one-mode individual-by-individual projection of this network pattern, the driving mechanism would be the network expansion. But if we make a one-mode firm-by-firm projection, the driving mechanism would be the network reinforcement.

For both groups of actors, forming the tie between individual X and firm A is potentially beneficial. Joining new corporate boards might be in the interests of individuals because new ties bring them career experience, increase their social status, and sustain elite group cohesion. Popular directors meet people on new boards and bring their connections from other boards to new boards. As a result, they have a significant function of connecting boards and transferring valuable information; their personal status and social capital increase as a result of accumulating these ties. Moving to the core of the network improves the position of a person in elite groups by expanding its network ties. As a result, elites can act as a group and promote their interests.

For firms, popular directors might serve as potential sources of valuable resources. The resource dependence perspective states that organizations are embedded in networks of interdependencies with other organizations (Salancik and Pfeffer, 1978). Their longevity and success depend on the ability to access external resources from the environment, and organizations need to take different actions to control already existing interdependencies. Organizations strategically seek these resource-providing interlocks in order to balance their dependence on external environments. One way to obtain resources for organizations is by appointing directors who already have a significant and well-connected position in the network. By appointing such directors, firms improve their position in the interlock network and obtain easier access to the variety of resources that these individuals bring. These directors not only provide their skills and expertise but also bring diverse and innovative practices from other organizations (Hillman and Dalziel, 2003). But in case of this network microstructure, when firm A simultaneously forms interlocks with firms B and C by appointing individual X, A does not go further its social environment, it improves already existing ties by reinforcing them.

If the interests of firms and individuals drive the network dynamics together, our first hypothesis will be:

H1. The probability of a board appointment increases over time with a person's increasing number of existing appointments.

If Hypothesis 1 is confirmed, we would conclude that the interests of firms and individuals coincided, firm-related and individual-related interests were together the drivers of new ties in the board interlock network. Firms are more likely to be driven by network reinforcement strategy while individuals are more likely to be driven by network expansion strategy. However, we will not be able to differentiate which type of actors was more significant for forming ties, whose interests were predominant. As we know from the previous literature, this is hardly ever possible. If Hypothesis 1 is rejected, we would conclude that this network configuration does not drive the dynamics of the board interlock network. We do not know exactly how the interests of firms and individuals created ties in this network but we would not make erroneous assumptions about the predominance of one group's interests over another.

For constructing the second hypothesis, we focus on another network microstructure, named 'six-cycles'. Its two-mode visualization is presented in the second row of Table 1. In the six-cycle, firms A, B, and C already share a few directors. An individual X is on board of a firm B and this individual can also join a board of a firm A. In one-mode individual-by-individual projection of this network pattern, individuals X and Z are connected by being on board of a firm B and individuals Z and Y are also connected by being on board of a firm C. There is an absent tie between individuals X and Y. If this tie will form, the triad will close: individuals X, Y, and Z will be all connected with each other. In one-mode firm-by-firm projection, firms A and B will also potentially form a tie with each other to close the triad between all firms A, B, and C. By sharing the same board members, firms strengthen already existing connections by creating one more additional tie.

Together, the prominence of six-cycles in the two-mode network dynamics will indicate the preference for the triadic closure that would signify that the reinforcement strategy is in place. Participation in six-cycles can be beneficial for firms and individuals. This network pattern brings benefits for firms in the form of increased coordination with other firms. They will reinforce their ties by creating bonds via sharing multiple board members and sustaining internal elite cohesion. Interlocking directorates are traditionally described as densely connected inner circles of individuals that are closed to outsiders (Mills, 1956; Useem, 1984). In the 'old boys' network', new appointments are typically based on previous affiliations, and individuals prefer to work with people they already know because the corporate elite accepts others with whom they share a common background and experience. These appointments are based on personal referral mechanisms; directors share common experience and know what to expect when serving on a new board (Davis et al., 2003). These reciprocal ties are valued by corporate elite members because they foster trust and solidarity and establish a basis for the creation of common norms. Dense networks allow the corporate elite to transfer economic or political messages and to promote its interests.

If firms and individuals have an interest in sustaining network reciprocity and reinforce already existing ties, six-cycle microstructures will form in the network of board interlocks:

H2. The probability of a board appointment increases over time when it results in a closing a triad of board interlocks.

If Hypothesis 2 is confirmed, we would conclude that the interests of firms and individuals together caused the formation and evolution of ties in the network. At the core of their interest is the network reinforcement strategy. If this hypothesis is rejected, we would conclude that the six-cycles were not significant network drivers in this board interlock network. It means that the formation of dense circles of interconnections is not a significant driving mechanism for both groups of actors. They might be more prone to connect with diverse groups of nodes in order to expand their social circles rather than to sustain triadic closure by reinforcing already existing ties.

Both hypotheses have a dynamic nature. We model the evolution of the network of board appointments; the consequent sequences of appointments are important for driving its evolution. Once an appointment happens, it lasts for some time and the board often does not open new positions for a period of time. It means that the internal time dynamics of this network is relatively slow. We take into account this network property, using a relatively long halflife parameter during our modeling.

In sum, we test two simple hypotheses using network microstructures that are already studied on one-mode firm-by-firm or individual-by-individual networks. We want to stress while testing these hypotheses that both groups of actors might be simultaneously interested in creating new ties. They might have different interests such as network reinforcement or expansion but if we use only one group of actors for the analysis, we omit the interests of another group. As a result, we do not know what were the driving forces creating ties in the network. In both microstructures, there is no one explanation for the formation of a potential tie that we can use, taking only firm-related or individual-related perspective. Their interests are intertwined and if we take only a firm-related perspective, we omit a large part of social processes that also take place in the network, namely, individual interests and considerations. Here, both firms and individuals will make potential considerations accompanied by a new appointment and will consequently come to a decision, realized or not realized in a new board appointment tie. The sequences of these appointments determine the formation of the whole board interlock network and define its further evolution.

5. Data and methods

5.1. The case of the Danish corporate elite

We test different explanations for board interlock dynamics through an analysis of the network of board appointments in Denmark from 1994 to 2014. Denmark is a high-income Scandinavian country with a mixed economy. It was usually classified as a coordinated market economy until it was shown that recently Denmark has adopted some features of liberal market economies and therefore can be classified as a hybrid type (Campbell and Pedersen, 2007; Rose and Mejer, 2003). The corporate governance system in Denmark is similar to corporate systems in other Scandinavian countries (Sinani et al., 2008), with a family-oriented ownership structure. These systems are not as relationship-based as in Germany and Japan but at the same time not as market-oriented as in the UK and the US (Rose and Mejer, 2003).

The business elite in Denmark has several distinct characteristics (Ellersgaard et al., 2013; Ellersgaard, 2016; Larsen, 2015). There are no educational institutions in Denmark that are considered to be elite or highly prestigious universities and therefore the majority of the corporate elite has a business or technical higher education, which makes it similar to the German business elite. The gender quota for corporate board positions does not exist in Denmark but corporate governance recommendations state that boards of state-owned companies should be diverse in gender, talent, age, international experience (Terjesen et al., 2015). Danish companies are recommended to implement their own targets and policies for gender quota and to report them. The country is in the process of integrating into the international business community and the largest corporations have some activities taking place at a transnational level; however, most corporate directors preferentially build their careers in Denmark and rarely move abroad. The Danish corporate elite is flexible in its career trajectories: its members change positions several times during their career paths and it makes them different from other European business elites such as the French or German ones, that diversify their careers less often. Also, the Danish corporate elite has not yet undergone significant fragmentation as, for instance, in the United States board interlock network (Chu and Davis, 2016; Mizruchi, 2013).

Denmark is a good empirical case for our study for several reasons. First, it has an economy that cannot be definitively related to the coordinated or liberal market types. It is not clear whether interfirm or interpersonal relationships matter most for the corporate governance system in this country. Denmark has a very well developed economy with a number of influential corporations at the European level, but at the same time, its corporate elite is relatively closed to international markets and is very densely connected within the country. Second, corporate directors in Denmark often have several positions throughout their careers, meaning that this corporate network has a significant number of board interlocks and is characterized by dense corporate and elite relations.

Finally, it is difficult to obtain high-quality data on board positions for a large number of corporations in one country and therefore most studies utilize small datasets of several hundred corporations gathered using corporate annual reports. We work with a large-scale database of corporate appointments to show the network evolution at a larger scale, taking into account the varieties of behavior exhibited by firms and individuals. With the aforementioned theoretical and empirical considerations, the high data quality for Denmark in our data source has also strengthened our interest in the corporate networks of this country.

5.2. Data sampling and cleaning

We source our data from Bureau van Dijk's ORBIS database (http://orbis.bvdinfo.com), an extensive database containing detailed information on organizations all over the world, including the positions held by individuals at these organizations. We first selected all current (as of September 2015) board of directors positions at firms with operating revenue of more than ten million US dollars. For each firm, we know an indicator of its size (based on operating revenue), economic sector, and type. For each director, we know nationality (Danish or non-Danish) and gender.

We have the history of board appointments together with their timestamps in the format "day-month-year". For example, director X has a current position in firm A which began on 1-Jan-2000. Also, this director X has current positions in firms B and C which began on 1-Feb-2005 and 1-Mar-2010. This situation corresponds to the network configuration of Hypothesis 1 which is also visualized in Table 1. We would like to note that each new board appointment of a director is an additional position to already existing positions. Our aim is to trace the history of the previous appointments of director X in order to understand which firm-related or individual-related mechanisms were involved in the dynamics of the board appointment network.

We restrict the history of appointments to 20 years, considering only those which occurred between 1994 and 2014. All new board appointments are current by the end of 2014. We further aggregate timestamps according to their corresponding calendar years. The monthly distribution of appointments over time is presented in Fig. 5. As we can see from this figure, the number of board appointments is increasing steadily over time, indicating that new ties are appearing between the modes of the network: firms and individuals. The final dataset that we use for our following analysis consists of 10,377 unique directors, 3,304 unique firms, and 14,893 board appointments.

5.3. Two-mode relational event modeling

To model the dynamics of the network of appointments, we use relational event modeling (REM), a behavior-oriented network model (Butts, 2008). REM has been successfully used to understand various types of networks such as contact and interaction networks (Leenders et al., 2016; Quintane and Carnabuci, 2016; Schecter and Contractor, 2017), networks of political action, conflict networks (Lerner et al., 2013; Malang et al., 2017), and organizational networks (Kitts et al., 2017).

This paper is the first to apply REM to two-mode board interlock networks. The central unit of analysis in this model is a relational event, represented as a tuple $e = (i, j, t)$, where i is a sender of an event, j is a receiver, and t is the time point at which event e happens. The REM approach is based on the assumption that most dynamic social networks can be represented as sequences of events, or tie creations. It is based on event history models with the additional inclusion of network dependencies as model covariates. REM is distinct from traditional event history models due to its assumption that the occurrence of new events depends not only on the personal attributes of actors but also on their past history of interactions with each other and with other actors in the network. In other words, new board appointments depend not only on the attributes of the firms and individuals that create this appointment

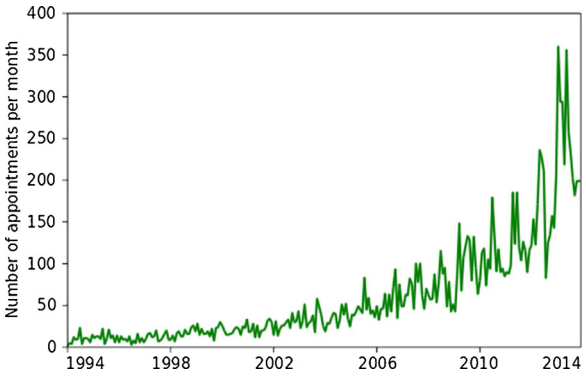


Fig. 5. Monthly distribution of board appointments.

but also on the past history of appointments of these firms and individuals with others in the network.

In comparison with traditional social network models such as exponential random graph and stochastic actor-oriented models (ERGM and SAOM), REM considers network ties as events rather than states (Butts, 2008). Another distinguishing factor relates to the way of dealing with observed and potential ties. ERGM models the network structure by comparing the observed network configuration with random networks and SAOM models the tie change of actors as a result of their decisions regarding the potential utility of new ties. In contrast, REM compares observed ties with potential ones and predicts the probability that potential ties will become observed. Adding a timing of events allows making causal conclusions about the observed network dynamics. Also, REM is flexible in modeling relatively large networks while simulating ERGM and SAOM models is computationally expensive and often infeasible (Stadtfeld and Block, 2017). Furthermore, modeling large graphs typically leads to convergence problems. REM compares observed ties with potential ones, a procedure not reliant on a large number of simulations and thus more easily scalable to large datasets, computationally and methodologically.

Our two-mode approach can easily be implemented in existing packages and does not require a different data structure. However, in ERGM or SAOM models, one or a few snapshots of network ties and actor attributes are used to model the network formation and evolution, while REM requires data with a larger number of time points. At the same time, the data points used in REM can be grouped into a fewer number of snapshots and hence can be modeled using ERGM and SAOM models. Modeling the network states over a larger number of time points using REM can give more detailed information about network formation and evolution processes than using ERGM or SAOM modeling. The main distinguishing characteristic of REM is in the flexibility in the number of actors over the time points. Having a fixed set of actors and the minimum amount of missing data over all network snapshots is important for ERGM and SAOM models. For this reason, friendship ties within school classes are typical data examples for these types of models. REM does not have these requirements on a stable number of actors; new actors can enter or leave the network over the course of the network formation. Therefore, contact and interaction networks are typical data examples of the data sources used for REM.

The application of REM techniques to two-mode networks remains limited, as calculating two-mode network covariates takes additional theoretical and computational effort. Here we use an approach presented in Malang, Brandenberger, and Leifeld (2017) and Quintane et al. (2014). First, we calculate two-mode network covariates which take place in the network of past events. Second, we use conditional logistic regression, estimated using the Cox proportional hazards model, which can be written as follows:

$$h(t)=\mathrm{h}_0(t) \times \exp(\beta_1 \times x_1+\beta_2 \times x_2 + \ldots+\beta_i \times x_i) \quad (1)$$

where $h(t)$ is the hazard of an event occurrence at time t, $h_0(t)$ is the baseline hazard, x_i are predictors and βi are coefficients of the predictors. The Cox model can be used for an estimation of REM because it allows the inclusion of exogenous covariates where the functional form of the survival curve is unknown a priori, i.e., we do not make any assumptions about higher or lower risks of survival over time. We model the risk that an appointment takes place at a current time point, given that it has not occurred in the past. The risk set is represented by all potential events that did not happen in the past between a firm and an individual but eventually will occur. The model is stratified and we treat each year as a separate stratum, assuming that baseline hazards of event occurrence might vary over the years.

The network statistics that can be included in REM are described by Butts (2008) and extended in various papers. Here, we use the network statistics described in Lerner et al. (2013), which we calculate using the 'rem' package in R (Brandenberger, 2018; R Core Development Team, 2017). Six-cycle network statistics were originally not implemented in the 'rem' package. We therefore wrote a new function in C++ with an interface in the 'rem' R package that computes six-cycles, based on already existing four-cycle statistics. The code to compute these six-cycles is available for reuse by other researchers and can be found at github.com/uvacorpnet/rem.

From here we adopt the notation used by Lerner et al. (2013) and Brandenberger (2018). Our network Gt represents the network of past events and includes all events E which happened before time t. Each event consists of a firm a that belongs to the set of firms A, an individual b that belongs to the set of individuals B and a weight function w_t which is applied to each past event:

$$G_t=\mathrm{G}_t(E) = (\mathrm{A},\mathrm{B},\mathrm{w}_t) \quad (2)$$

In this specification of REM, we use weighting because recent events are assumed to have a stronger influence on new event occurrence than events that happened further in the past. The weighting function $w(i,j)$ counts the number of events between a firm i and an individual j which occurred in the past and then weights them based on their recency:

$$w_t(\mathrm{i},\mathrm{j}) = \sum_{e:\mathrm{a}=\mathrm{i},\mathrm{b}=\mathrm{j}} |w_e| \times e^{-(t-t_e)\times\left(\frac{\ln(2)}{T_{1/2}}\right)} \times \left(\frac{\ln(2)}{T_{1/2}}\right) \quad (3)$$

where w_e is the weight of the event, t is the time of a current event, t_e is the time of a past event, and $T_{1/2}$ is a halflife parameter. The vector of past events is weighted by an exponential decay function using the specified halflife. The halflife indicates after how long the event weight should be halved. A smaller halflife parameter gives more weight to events that happened in the recent past, while a larger halflife measures the long-term effects of past interactions. For all network-related statistics, we use a halflife parameter of 2 years. We ran robustness checks of the models with halflife parameters of 1, 3, 4, and 5 years and found that results remain stable for different parameter values.

The microstructure variables of past popularity of directors and six-cycles (see Table 1) are defined as:

$$\text{Popularity of directors}(G_t,\mathrm{a},\mathrm{b}) = \sum_{i\in A} w_t(\mathrm{i},\mathrm{b}) \quad (4)$$

$$\text{Six}-\text{cycle}(G_t,\mathrm{a},\mathrm{b}) = \sqrt[5]{\sum_{i\neq k\in A, j\neq l\in B} w_t(\mathrm{a},\mathrm{j}) \times w_t(\mathrm{i},\mathrm{b}) \times w_t(\mathrm{k},\mathrm{j}) \times w_t(\mathrm{i},\mathrm{l}) \times w_t(\mathrm{i},\mathrm{j})} \quad (5)$$

All network covariates are standardized using the (standard) z-score in order to make them comparable. Director popularity and six-cycles are positively correlated; the Pearson correlation is 0.22. We delete the first 4 years to avoid bias in the estimation of network covariates. The deletion of this number of cases is based on the approach mentioned in the 'rem' package that suggests deleting the first events for a duration equal to two times the halflife (Brandenberger, 2018). This ensures that there is no bias in the estimation of network statistics because the first events have very few events to look back at. The estimation of the models was done using the 'survival' package in R (Therneau, 2015). Descriptive statistics for variables are presented in Table 2.

Note that our research design is different from the broken ties literature mentioned above. We do not model the tie termination nor reconstitution. We also do not focus only on the firm-by-firm network. In contrast, we aim to understand tie formation in two-mode networks of board interlocks. Ties in these networks are board appointments that take place between firms and individuals. These appointments are events with duration because once an appointment happens, it lasts for a certain time period. Our interest here is in understanding the driving mechanisms of new board appointments and the subsequent formation of board interlocks.

6. Results

We build several groups of models that are presented in Table 3. The

Table 2
Descriptive statistics of actor-related and network-related variables.

	Mean (SD)	Min	Max
Number of appointments per director	1.44 (1.02)	1	17
Number of appointments per firm	4.51 (2.41)	1	22
Number of days on board	2,255 (1,760)	335	8,004
Operating revenue of firms, in thousand US $	275,206 (1,479,987)	10,002	50,538,000
Banks and financial institutions	0.09	0	1
Female directors	0.14	0	1
Directors with non-Danish nationality	0.12	0	1
Director popularity	0.00 (1)	−0.19	24.51
Six-cycles	0.00 (1)	−0.03	141.35

first and third models test two hypotheses. The second model is an additional control of the non-linearity of directors' popularity. The fourth model includes the popularity of directors and the six-cycles together in order to test both hypotheses in one model. To obtain unbiased estimates of relational event models, we include control variables related to attributes of actors together with endogenous network covariates in Model 5.

The sizes of effects in models are interpreted as in a logistic regression model. For example, an estimated value of 0.056 for director popularity in Model 1 shows that an increase of one standard deviation in a director's popularity leads to exp(0.056) = 1.057, or a 5.7 % increase in the likelihood of this director being appointed. Being a male director in Model 5 is associated with exp(0.106) = 1.112, or an 11.2 % increase in the probability of being appointed. We standardize all network variables to make them comparable over time and between each other. One standard deviation increase in the network variable indicates that the specific network pattern took place significantly more often in the past, in comparison with the mean number of occurrences of this network pattern.

Model 1 tests our first hypothesis about the tendency of popular directors to attract more corporate appointments. The positive effect of popularity indicates that directors who already have many appointments in the near past are more likely to be appointed to new board positions. The quadratic popularity in Model 2 controls for non-linearity of the observed network microstructure. We find a negative and significant estimate of a squared popularity of directors together with a positive estimate of non-quadratic popularity, which indeed suggests that there is a non-linear relationship. Directors cannot join an infinite number of boards and firms cannot appoint new directors endlessly. Individuals are likely to accept new appointments up to a certain point, but when they already have a large number of concurrent positions, their propensity to participate in more boards decreases. The findings from these models confirm the first hypothesis. While firms seek for reinforcement of already existing ties, individuals seek for expansion of their connections. Corporate and individual interests match and together drive the evolution of this network.

Model 3 tests the second hypothesis where we measure the social cohesion of corporate elites and firms by the creation of six-cycle microstructures in the network. The results show that there is a tendency for potential six-cycles to close. This supports the second hypothesis. Six-cycles form when elite group members seek for within-group social cohesion and firms close in triads to coordinate their behavior with other firms. We conclude that since the six-cycles tend to form over time, individual and firm interests do drive simultaneously the evolution of the observed network. Firms and individuals seek for the reinforcement of already existing ties.

Model 4 includes network covariates that test both hypotheses in the same model. It allows us to observe potential changes in strength and significance effects. We see that the direction and the significance of the popularity remain the same while the effect of the six-cycles disappears. This might be the result of the stronger driving force of the director popularity in the network. Six-cycles contribute to the evolution of the network but the past popularity is a stronger predictor of future ties.

The final Model 5 includes a set of actor-related controls to existing network-related covariates. Board interlocks are driven in part by previous network states of firms and individuals. However, the personal characteristics and attributes of these actors also determine the creation of new appointments and drive the evolution of the whole network. For example, individual-level characteristics such as directors' gender and nationality are arguably relevant predictors of their future appointments because many corporate boards are occupied by old boys' networks, and the majority of interlock networks are represented by national business communities (Edling et al., 2012). Most boards remain very homogeneous and closed to external environments despite studies showing that some level of diversity is beneficial for firms (Miller and Triana, 2009). Firm-related characteristics that are arguably relevant predictors of new board appointments and concomitant interlocks include size measured in operating revenue and the type of the enterprise. Firms of various sizes differ in their interlocking behavior (Lynall et al., 2003; Zahra and Pearce, 1989): interlocks may be more beneficial for small firms as potential resources while large firms may be more valued as interlocking partners because of their closeness to valuable resources, capital flows, and other central actors. Also, banks and financial institutions traditionally have a very distinct role in interlock networks, as they are very central and densely connected with other enterprises in the networks of board interlocks (Mizruchi and Stearns, 1988; Pfeffer, 1972). The fifth model includes actor-related controls such as individuals' gender and nationality and operating revenue and the type of firms. Thus, it combines network-related covariates with actor-related controls. At the individual level, we find that male directors and Danish nationals are more likely to be appointed to boards over time. For firm-level controls, we do not find any significant differences in the network behavior of firms of different sizes. However,

Table 3
Modeling results, standard errors are in parentheses. Dependent variable is the probability of a board appointment.

	(1)	(2)	(3)	(4)	(5)
H1: Popularity of directors	0.057*** (0.004)	0.145*** (0.009)		0.145*** (0.009)	0.111*** (0.010)
Popularity of directors squared		−0.008*** (0.001)		−0.008*** (0.001)	−0.006*** (0.001)
H2: Six-cycles			0.010*** (0.003)	0.000 (0.003)	0.000 (0.005)
Male directors					0.106** (0.039)
Directors with Danish nationality					0.175*** (0.030)
Operating revenue					0.000 (0.000)
Financial institution or bank					0.108** (0.037)
Number of observed events	14,406	14,406	14,406	14,406	8,454
Number of potential events	183,357	183,357	183,357	183,357	103,185
McFadden R-square	0.001	0.001	0.000	0.002	0.002
Likelihood Ratio Test	178.9	291	11.87	291	227

Note: ** p < .01, *** p < .001.

financial institutions and banks are more likely to participate in interlocks over time in comparison with firms from other sectors. Note that after adding the actor-related control variables, the significance and the direction of the popularity remains the same and six-cycles remain non-significant.

While the explanatory power of the models is relatively modest (as we see from the R-square values), the consistency and stability of covariate effects over the models show a robust result. Likelihood ratio tests demonstrate that the estimated models fit the data significantly better than null models or models without any predictors. The models including the popularity of directors predict the formation of new appointments slightly better, but the inclusion of both variables testing our two hypotheses explains the creation of new ties in a more detailed way. In sum, the modeling results show that both firm-related and individual-related interests drive the dynamics of board interlock networks.

7. Discussion and conclusions

Revisiting a classical yet unresolved debate, we engaged with the question of how individuals *and* firms drive the formation of board interlock networks. We argued that the literature that investigates board interlock causes and dynamics suffers from a division that runs along the lines of actor orientation. The organizational perspective predominantly understands board interlocks as means for firms to reduce uncertainties and access resources. The individual-oriented perspective, on the other hand, stresses how board interlocks underpin social class structures and create elite social closure. In response to this persistent controversy, we developed a theoretical and empirical framework that considers both personal and organizational interests as drivers of board interlock dynamics. Theoretically, we developed a model in which firms and individuals simultaneously make decisions about their network strategies and consequently make a decision about creating or not creating a board interlock tie. Empirically, we applied two-mode relational event modeling as a practical and promising approach for studying social network dynamics with more than one group of actors.

The results of our study show that organizational and individual perspectives are complementary rather than conflicting. In the case of Denmark, we find a high propensity of board interlock network microstructures that reflect both organizational and individual interests. This means that when the broken tie studies asked whether firms or individuals are the drivers behind board interlock creation and maintenance, they may have been asking the wrong question. Our results show that both firm *and* individual drivers play a role in the evolution of board interlocks and we demonstrated the possibility of studying their joint decision making both at theoretical and empirical levels.

For some, it may come as no surprise that our results show how board interlock formation is simultaneously driven by organizational and individual mechanisms. The network formation properties, revealed in this paper, have been established in numerous papers on corporate networks. The surprise may rather be that, given the arguably obvious nature of our results, the persistent calls for a proper two-mode approach to board interlock formation have remained largely unanswered. In general, the disciplinary borders and divisions of literatures are difficult to overcome, especially when an empirical strategy requires sophisticated and innovative methods. We consider this as a theoretical-methodological conundrum that is difficult to disentangle. We hope that with our contribution we have made the first step towards this disentanglement. The novelty aspect of this paper is in demonstrating a new theoretical and empirical approach to investigating the duality of persons and groups in social networks. We show that competing drivers of ties may co-exist in one social system. Revealing these patterns is not restricted to our methodological and empirical approach, we believe that similar results can be obtained, using two-mode network models such as two-mode SAOM or two-mode ERGM. A potential drawback of REM, however, is that it is not able to capture a dependence between a local tie and ties situated elsewhere in the network. Actors can react to signals outside of their closest network neighborhood and coordinate behavior in relation to actors located further away in the network. This issue of measuring these influences coming from further located ties can be a further extension of the presented analysis.

Building on the case study of Denmark, we believe that our approach also opens up new research avenues for a comparative analysis of corporate governance systems across the globe. Corporate networks are a well-known element in the varieties of capitalism, and our approach makes it possible and practical to not only compare static snapshots of board interlock networks across countries but to comparatively study the mechanisms that generate them. Comparing across countries, we would expect to find stronger effects for organization-related drivers in countries closer to liberal market economies, and stronger effects for individual-related drivers in countries closer to the coordinated market economy model (Soskice and Hall, 2001; van Veen and Kratzer, 2011). Comparative studies, however, need to take into account a variety of corporate governance policies that can influence board appointments. For example, gender quotas (e.g. Terjesen et al., 2015), requirements for a minimum number of independent directors (e.g. Duchin et al., 2010), and increased regulatory responsibility for executives (e.g. Withers et al., 2018) will affect new corporate board appointments. Comparing global corporate networks over time and taking into account local policies, our approach can track the dominance of individual and organizational drivers and their changes relative to each other. The latter would, however, require serious advances in data quality and availability across different countries. In the case of Denmark, we found that the majority of ties are created in the interests of both groups of actors that can be explained with a hybrid type of market economy typical for Denmark (Campbell and Pedersen, 2007; Rose and Mejer, 2003).

Another avenue for future research is the influence of node properties on network strategies of firms and individuals. Individual properties that allow studying the role of diversity in network creation and dynamics would be the first step for future research. For example, in the case of gender, potential female appointments would influence the network building strategies of homogeneous and heterogeneous boards in different ways. Also, cross-country comparison with additional node attributes might show that individual characteristics influence the dynamics of the network in different ways, depending on the institutional settings of countries. Further studies also require methodological innovations in the field of dynamic network analysis. For example, one of the network building strategies that we do not address in this paper is a brokerage strategy. It can be measured using the network distance but implementing the distance would be computationally expensive at the moment. This issue requires computational innovation and more efficient network algorithms.

Our work may also inspire new empirical studies on the diffusion of practices between interlocking boards. For instance, Shropshire (2010) presents a multilevel theory of diffusion of practices through interlocks that have not yet been empirically tested. In her model, there is a two-mode understanding of the diffusion process: board members transfer the practice and the board of the firm accepts or rejects the practice. Individuals and boards together participate in the process of the transmission. However, as we pointed out throughout our paper, this multilevel aspect of the transmission is usually ignored in the theoretical and empirical literature. Using our approach, i.e. including attributes of individuals and boards to the model, it is possible to further test Shropshire's theory empirically and predict how the practice transmission would spread in the network. This allows us not to ignore the agency of both groups of actors and control for contextual and network effects that together drive the transmission of relevant practices. The approach presented in this paper seems well suited for the empirical testing of multilevel theoretical models, similar to the board practice transmission model of Shropshire (2010).

Our work also speaks to a more fundamental discussion on the duality of actors in social systems (Breiger, 1974). To what extent can we separate the actors from the groups they are embedded in? Our response to this core issue of social science is to make an effort to include both the individuals and the social groups as actors that contribute to network tie creation. We accept that it is difficult to detach organizational interests from individual interests, but choose not to ignore them but rather treat them as part of one social system. We recognize that the research design we have developed here lends itself to application in different settings. Most empirical cases consisting of organizational and individual units face similar situations of contradicting interests. In the socio-economic world, it is common for individuals to be embedded in social groups: employees are affiliated with organizations or unions, students study at schools, and online users are members of interest groups. These literatures typically suffer from the same problem as board interlock literature: neglecting ties between individuals and groups and focusing on only one type of actors. This actor choice is usually theoretically informed and as such is not a mistake per se. But often it is possible to present an alternative theoretical explanation which would require the inclusion of the other set of actors. Most socio-economic systems are characterized by the duality of actors, and their agencies should no longer be ignored. With new methodological techniques and large datasets about human and organizational behavior, it has become possible to solve classical theoretical debates that have gone unresolved for decades. It is challenging to revise our conventional ways of thinking about actor behavior in social systems, but if we are able to overcome these barriers, we will gain new insights about the beauty of complex social systems.

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Appendix A. Supplementary data

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