A comparative analysis of the dynamics of interlock networks among immigrant organizations

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Abstract

Social capital is naturally embedded in social networks. In his famous work on the causal relationship between "bridging" social capital (e.g., associational life), trust, and civic behavior, Putnam [1993] did not investigate the structural aspect of such networks. Recently, the relationship between associational life and civicness of ethnic minority groups in Europe has been investigated [Fennema and Tillie, 2001; Jacobs et al., 2004; Vermeulen and Berger, 2008], without reaching uniform conclusions. In this work, simple structural properties of the network of interlocking directorates among ethnic associations are used as a proxy of the social capital of the corresponding minority group. We pursue this line further, arguing that more advanced models may consistently predict differences among the studied communities, and look at the structure of such networks,but also at the dynamics that produced it. Here we present results with a stochastic actor-based model, SIENA [Snijders et al., 2010], which estimates the effect of actor covariates and local structure on network evolution. We model the dynamics of the full two-mode network among directors and boards of voluntary associations, including the structural effects proposed by [Koskinen and Edling, 2012], and considering the political orientation of associations as a covariate. Using data from [Vermeulen and Berger, 2008], we compare the evolution of interlocks among Turkish associations in two European capitals, and explain the noticeable difference in structure by looking at statistically significant differences among the estimated effects. In the longer term we intend to relate the dynamics of these networks to the civic behavior of the corresponding communities.

Keywords: Civil Society, Migration, Political Participation, Social Capital, Ethnic Minorities, Interlocking Directorates, 2-Mode Networks, Siena, Dynamic Network Analysis.

1 Introduction

Social capital designs the ensemble of resources which are accessible to a social actor through its relationship with other actors [Castiglione et al., 2008]. As such, it is naturally embedded in social networks, where nodes represent actors (e.g. individuals, political groups, associations), and links represent relationships (e.g., friendship, common interests, hostility) [Burt, 2000]. In his famous work on the causal relationship between "bridging" social capital (associational life), trust, and civic behavior, Putnam [1993] did not investigate the structural aspect of such networks, leaving the question of its relevance unstated.

Recently, the relationship between associational life and political participation of ethnic minority groups in Europe has been investigated, obtaining useful insights, yet without reaching uniform conclusions [Jacobs et al., 2004; Tillie, 2004; Vermeulen and Berger, 2008]. In this line of work, simple structural properties of the network of interlocking directorates among ethnic associations have been used as a "proxy" of the social capital of the corresponding minority group.

The aim of our research is to pursue this line further: We argue that more advanced models may consistently predict differences among the studied communities, and look at the structure of such networks, but also at the dynamics that produce it. Intuitively, the dynamics of a social network will be related to the characteristics of the individual actors involved, but also of the larger society in which they take part. Shedding light on the interplay among local and global features and network dynamics may therefore be crucial to improving our understanding of social phenomena.

The research we present here is aimed at quantifying the dynamics of interlocks among ethnic minority associations. To this end, we use a stochastic actor-based model, SIENA [Snijders et al., 2010], which estimates the effect of actor covariates and local structure on network evolution. We start by analyzing data from [Vermeulen and Berger, 2008], describing the boards of Turkish associations in Amsterdam and Berlin. In a later stage, after extending the analysis to other data sets, the effects which are found to be significantly different among the communities will be used as additional independent variables, along with more traditional socio-economic indicators, in order to explain the observed differences in political participation.

2 Background

Social capital. This concept, central to sociological research, designs the ensemble of resources that an actor can access or mobilize via his connections to other actors, regardless of the kind of resource considered (information, control, support, etc.). Most of the early work on social capital focuses on individuals, or small elite groups [Portes, 1998]; its study at the *aggregate* level, for a whole community, has been popularized by Putnam [1993], who observed a virtuous circle of causal connections between the amount of associational life, the level of trust, and civic behavior.

More recently, Fennema and Tillie [1999, 2001] compared the social capital of four migrant communities in Amsterdam, in order to measure its impact on civic behavior. Studying structural differences among the networks of interlocking directorates of ethnic organizations (i.e., connections among organizations sharing one or more board members), the authors found a positive correlation among the density of interlocks, and the political participation of the corresponding ethnic minority group, arguing that such density, allowing for information to circulate among different organizations, can be used as an indicator of the social capital embedded in a community. The authors also claimed the existence of a "rainmaker effect": also those members of a community who are *not* directly engaged in a voluntary organization would benefit from the ethnic social capital of their group, showing higher levels of political participation and trust.

Later studies (see [Jacobs and Tillie, 2004], and other papers from the same special issue), where the same methodology was applied to data from other communities, questioned this hypothesis, finding more subtle relationships among organizational network structures, aggregate indicators of immigrant groups, and civic behavior. To date, no definitive answer has been given to the questions raised by Fennema and Tillie; Jacobs et al. [2004] compared Moroccan and Turkish communities in Brussels, using sequential regression analysis, questioning the rainmaker effect on the aggregate level, and stressing the importance of gender and cross-cultural social capital (affiliation to non-ethnic organizations) to explain political participation on the individual level. Vermeulen and Berger [2008] studied Turkish communities in Amsterdam and Berlin, finding instead a *negative* correlation among organizational network density and political participation, justified by the intuition that a solid and influential network of ethnic associations in Amsterdam allows members of the community to delegate political activity to the associations themselves. In the recently completed European project *LocalMultiDem* [Morales and Giugni, 2011], the issue has been investigated for different immigrant groups in seven countries: the effect of associational life was mostly studied at the individual level, and its effect was found to depend on the political opportunity structures of the host country.

Networks. The relationship between social capital and network structure has been extensively investigated, but mostly focusing on *individual* social capital [Borgatti et al., 1998; Lin, 1999; Burt, 2000]: in this work, the authors relate static structural features of the social network of individuals, or organizations, to their performance, mostly in the economic sense. A more recent approach is proposed by Van Der Gaag and Snijders [2005]. One concept that has been broadly applied is that of *structural holes* [Burt, 2000]: actors who have a larger number of ties with other actors who are *not* connected with each other are regularly observed to have a higher status. The hypothesis is that these individuals can act as a *broker*, forming a communication channel among unrelated parts of their social network, and exploiting this to their advantage.

In our research, we are interested instead in *aggregate* social capital, at the level of a whole community of actors: while Borgatti et al. [1998] proposed research in this direction, to our knowledge this aspect has been not investigated further. Putnam's original work [1993] only compared the number of associations, relative to population size[1] ; the work on ethnic social capital described above considered simple global measures, such as the number of organizations and interlocks, the density of interlock networks, and the number of isolated

[1] In the last part of the book, Putnam does argue that the differences observed among Italian regions may be related to differences in the underlying social networks structures, distinguishing among the "horizontal" relations of the civic society, and the "vertical" ones of patronage, corruption, and mafia: however, this distinction is left at a purely qualitative level.

nodes [Fennema and Tillie, 1999, 2001; Vermeulen and Berger, 2008].

Dynamic networks. The current flourishing research on this topic [Doreian and Stokman, 1997; Snijders and Doreian, 2010] did not so far permeate mainstream research on social sciences, and social capital in particular, however its potential has been recognized [Diani and McAdam, 2003].

The two most widely used generative models share the assumption that network dynamics are influenced by features of the network itself (structural features, as well as nodes and ties covariates). In Exponential Random Graph Models (ERGM, also called `p*`) [Anderson et al., 1999; Robins et al., 2007], the probability distribution that generated the observed network is estimated as a function of covariates of both nodes and ties. In SIENA [Snijders, 2001; Snijders et al., 2010], the estimation of the importance of different structural features and covariates is based instead on two or more snapshots of an evolving network. A similar approach is proposed by Opsahl and Hogan [2011].

Two-mode networks. Interlocking directorates are an example of *two-mode* or *bipartite* networks, where two classes of nodes are present, and links are only possible from one class to the other. In the case of interlocks, the two classes correspond to directors and boards [Fennema and Schijf, 1978]. Other examples are e.g. co-authorship networks, linking authors to their papers [Newman, 2001], and co-attendance networks, linking people to events they attended [Davis, 1941]. In all these cases, a projection onto two distinct *one-mode* networks can be performed, linking two nodes if they are connected to a same node of the other mode. In the case of interlocks, this allows to draw a network among boards that have at least one director in common; or among directors that sit on the same board.

As one mode networks have been the subject of a much larger corpus of research, and software development, many scholars prefer to analyze one of the projections, discarding the two-mode data: e.g., the network of interlocks among boards, or the network among co-authors, or individuals attending the same event. While not devoid of interest, this approach has several limitation, in that some of the information in the data is lost during the projection (e.g., in the case of boards, multiple common directors). Moreover, it has been shown that the projection introduces spurious structures in the one-mode network [Newman et al., 2001], which render some of the standard network measures, such as density and clustering, void of their original meaning [Opsahl, 2011] (See also Sec. 3.1).

Recently, a number of important innovations have been introduced, which allow to address two-mode data directly, without the need of a projection. Opsahl [2011] introduced a novel clustering measure for two-mode networks, while Koskinen and Edling [2012], and Wang et al. [2012], respectively extended SIENA and ERGM.

3 Objectives

The general aim of our research is to improve our understanding of the nature of social capital, and of the role it plays in the functioning of a community. We focus in particular on ethnic minorities: following an established practice in this area of research, we consider the structure of interlock networks among voluntary associations, and the commitment in the non-profit sector in general, as indicators of social capital, with the aim of relating them to the trust and civic behavior of immigrant communities. Attempts to use network structure indicators, such as density, as independent variables to explain civic behavior have already been carried out (see Sec. 2): our main aim in studying network dynamics is to quantify its features, in order to add them as further explanatory variables to the analysis.

The present work describes a first analysis of interlock dynamics, aimed at identifying the factors which govern the evolution of interlock networks, to be used at a later stage as independent variables in explaining the political participation of the corresponding ethnic minority groups. As a starting test case, we considered the interlocks of Turkish associations in Amsterdam and Berlin, as they display strikingly different properties [Vermeulen and Berger, 2008]: the network in Berlin presents hierarchical, star-like structures which seems absent in Amsterdam, characterized instead by cliques of organizations forming multiple interlocks (see Fig. 5). In both cases, the networks are strongly polarized according to political orientation.

We will later repeat our analysis on the data of the same community in Brussels, and extend it to available data on other ethnic minorities, such as Moroccans (Brussels, Amsterdam), and Congolese (Brussels), including available covariates such as religious affiliation, field of activity, and allocated funding. In the longer term, we intend to answer questions on causal connections among these variables, the structure and dynamics of the observed networks, and global indicators of trust, political involvement, and civic behavior of the corresponding communities. For example, what is the impact of funding policies on associational life? Which policy is more successful in encouraging the political participation of ethnic minorities? What distinguishes associations that thrive from others that are quickly dissolved?

3.1 Methods

SIENA Snijders et al. [2010] is a stochastic *actor-oriented* model of network evolution, meaning that the structure of observed network data is assumed to be the result of the actions of a set of agents, each corresponding to a node, and exerting a control over its outgoing ties, by adding or deleting ties to the other nodes. Given a set of potential motives governing social choices, mathematically defined as *effects*, the algorithm estimates a set of parameters, each modulating the impact of the corresponding effect on the probability of forming and deleting ties. Based on a pair of snapshots of an evolving network, the estimate is performed such that, in a simulation starting from the first snapshot, the final simulated snapshot will be the most similar to the one actually observed. In the following, we provide a simplified description of the model, based on [Ripley et al., 2012] and [Koskinen and Edling, 2012].

Be $\mathbf{x} \in \{0,1\}^N$ the binary matrix representing a network among N nodes, and $\Delta_{ij}\mathbf{x}$ the matrix obtained by switching a single element of $\mathbf{x}$, $(x_{ij} \leftarrow 1-x_{ij})$. Each node i is an agent, which can perform atomic changes to its outgoing ties x_{ij}, at exponentially distributed points in time, with rate λ. Agents add and remove links according to a "perturbed" utility function: the target index j is drawn with probability[2]

$$p_i(j|\mathbf{x}) = \frac{\exp \Delta f_i(j, \mathbf{x})}{1 + \sum_j \exp \Delta f_i(j, \mathbf{x})}, \tag{1}$$

where $f_i(\mathbf{x})$ is the utility of $\mathbf{x}$ according to i, and

$$\Delta f_i(j, \mathbf{x}) = f_i(\Delta_{ij}\mathbf{x}) - f_i(\mathbf{x}) \tag{2}$$

is the variation in utility that would be obtained by i with a switch of x_{ij}.

The utility function itself is a linear combination of *effects*, which can be arbitrary functions of the current network $\mathbf{x}$, as well as of node covariates:

$$f_i(\mathbf{x}) = \sum_k \theta_k s_{i,k}(\mathbf{x}). \tag{3}$$

Usually, the structural effects can be decomposed according to the outgoing ties of i, as

$$s_i(\mathbf{x}) = \sum_j s_i(j, \mathbf{x}); \tag{4}$$

In the following we will therefore drop the argument $\mathbf{x}$ to simplify the notation. Note that the model is Markovian: at each time step, the probability distribution over the possible next states (all networks at Hamming distance 1) can only depend on the current state. Fixing a set of effects and an initial network $\mathbf{x}$, its further evolution will be a stochastic function of the rate λ and the effect weights $\boldsymbol{\theta} = \{\theta_k\}$. These parameters can be estimated with a Markov chain Monte Carlo approach, selecting those values which produce networks that are the most similar to the ones observed, in terms of the aggregate values of the included effects: given an observed sequence of two of more waves of network data, numerous stochastic trajectories are simulated over the time span of the data, and the discrepancy between the observed aggregate values of the effects, and the average of those obtained from the simulations, is minimized. Various methods have been devised to this end: in our experiments, we used the default Robbins-Monro approximation.

A simple example will be helpful to clarify the method. Suppose we are given two subsequent waves of network data, describing friendship relationships in a given group: e.g., pupils in a same class interviewed on two consecutive years. Given this data, we would like to see if the old saying "the friends of my friend are also my friends" holds in this case. If so, we should see a certain tendency to "close triangles" from one wave to the next.

The question can be posed in quantitative terms using SIENA, by defining an effect $s_i(j)$ which evaluates to 1 for ties to friends of i's current friends, and 0 for ties to other unrelated agents (Fig. 1). If the effect parameter is positive, this means that, given the initial data, a simulation of network evolution will tend to close the open triangles. Estimating the parameter in order to match the observed value of the number of closed triangles, then, offers a principled, quantitative method to asses the importance of this effect in the data: an effect which turns out to be significant and positive can be interpreted as a tendency to transitivity in making friends.

[2] The 1 at the denominator is added to allow for "skipping" the change, and leaving the network as is, which happens with probability $\frac{1}{1+\sum_j \exp \Delta f_i(j)}$.

SIENA is currently available as an `R` package [Ripley et al., 2012], and it comes with a large number of predefined effects: e.g., to carry out the experiments above, we should include one called `transitiveTriplets`. Also covariates of the nodes can be used in defining effects: for example one could study the effect of gender, social status, behavior on the evolution of a social network, e.g. testing if *homophily* is present.

The standard deviation of effect estimates can be used to test their significance with a simple t-test. Also differences among an effect estimated on distinct data sets, or distinct waves, can be tested for significance [Ripley et al., 2012]; however, comparing among different effects is not trivial, as the magnitude of an effect is not a relevant index of its actual impact on network evolution, which depend also on the associated effect function. What matters in interpreting the results is the sign of significant effects.

Two-mode structural effects. As previously pointed out (Sec. 2), analyzing the one mode projection of two-mode data can be misleading. The resulting links in the one mode projection do represent meaningful relationships among the nodes involved, however their number grows combinatorially in the number of common nodes in the remaining mode: a node with degree $k \geq 2$ in the two-mode network will result in $\binom{k}{2}$ ties in the projection on the other mode (See Fig 2).

Studying projections is especially problematic with SIENA, as the basic assumption of atomicity of changes (agents can only change one link at a time) is violated: for example, by joining a new board, a director that sits already on k boards will add k new links at once in the projection, among the new board and the previous ones. Luckily for us, the method has been recently extended to two-mode networks by Koskinen and Edling [2012], who applied it to model the evolution of interlocking directorates among firms in the Swedish stock market. Using a carefully chosen set of novel effects, they highlighted the role of *peer referral* in reinforcing such interlocks; considering gender of directors as a covariate, they further showed that such role is limited to an "old-boy" network of male directors.

Four structural effects are considered as relevant for interlock formation (see Table 3.1). Aside from the basic outdegree effect, `density`, the authors consider the simple and double interlocks, labeled `2-star` and `4-cycle` respectively, and an intermediate structure termed `3-path`. The resulting four effects have distinctly different meanings: while `density` is a "baseline" expressing the tendency of associations of acquiring a new director[3], `2-star` corresponds to the tendency of forming an interlock, which may indicate an underlying social connection among the new director and members of the board, or reflect a strategy of the two boards; and `4-cycle` amounts to adding a second interlock to an existing one, which is interpreted by Koskinen and Edling [2012] as a stronger clue of *peer referral*: the fact that at least one of the directors sits already on both boards implies that he knows already all directors involved, and may suggest that one of his colleagues from the first board joins the second one, thus doubling the interlock. The `3-path` is added for completeness, as an alternative explanation to `4-cycle` formation, and may be interpreted as a differential preference of forming interlocks towards associations with a larger number of

[3]The mode of the organizations is considered the active one, unilaterally deciding when to add/remove directors. More advanced consensual models are available for one-mode undirected networks.

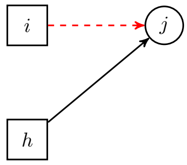
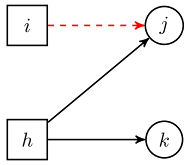
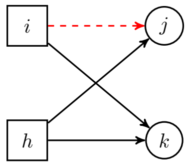
`density`	$s_i(j) = x_{i,j}$	
`2-star`	$s_i(j) = x_{i,j} \sum_{h \neq i} x_{i,j}$	
`3-path`	$s_i(j) = x_{i,j} \sum_{h \neq i} x_{i,j} \sum_{k \neq j} x_{h,k}$	
`4-cycle`	$s_i(j) = x_{i,j} \sum_{h \neq i} x_{i,j} \sum_{k \neq j} x_{h,k} x_{i,k}$	

Table 1: The structural effects used by Koskinen and Edling [2012], along with their graphical representation: `2-star`, `3-path`, `4-cycle`. Squares indicate boards, while circles indicate directors. Pictures are copied from original paper, formulas are ours so they may differ from their implementation.

directors.

Node sets composition change. The original version of SIENA was designed to deal with a constant number of nodes, which is of course unpractical when working with real data. While a modification to correct this issue was proposed Huisman and Snijders [2003] and is available in the code, its implementation for two-mode networks is still lacking. Moreover, while the creation and cessation of an association is well defined in time, it is not clear how directors should be considered while they're not engaged by a board: they could be available and willing to serve in a board, or not even be in the country[4]. A simple turnaround proposed by Koskinen and Edling [2012] consists in repeating the analysis for subsequent pairs of waves. This has two advantages: keeping the noise relatively contained (few differences between node sets of consecutive waves), without introducing additional hypotheses; and underlining variations in network effects over a period of several years. This latter aspect is particularly important for us, as it allows us to study longitudinal variations in the dynamics.

4 Results

The analysis was carried out using the `RSiena`, the `R` version of SIENA [Ripley et al., 2012]: in the following we illustrate the details of the experiments, and the results obtained.

[4] We owe this remark to Filip Agneessens.

Data. Longitudinal data (1980-2003) of the interlocking directorates among Turkish associations in Berlin and Amsterdam, used in [Vermeulen and Berger, 2008], was provided by the authors. The data has been grouped in waves, one per year, discarding observations before 1985 as they presented very few interlocks. Vermeulen and Berger also broadly classified the organizations according to their political orientation, on three levels (left, center, right, which were encoded as -1, 0 and 1).

Settings. Following Koskinen and Edling [2012], the boards mode was considered the active one, choosing which directors to recruit and release. As several waves of data were available, we initially analyzed waves by pairs, but we found that considering three or more waves at a time produced more stable estimates, with smaller standard deviations. The results we present here are obtained using a shifting window of three consecutive waves (four years).

Effects. Two of the effects used by Koskinen and Edling [2012] were not available in `RSiena`, and had to be implemented (`2-star` and `3-path`). The formulas used are reported in Table 3.1, and are our own interpretation, so they may differ slightly from the ones used by them. `4-cycle`, and obviously `density`, were instead already available.

For covariate effects, Koskinen and Edling [2012] considered the effect of director covariates (age and gender) on link formation. Given our application, we found it more relevant to look at features of the associations instead, as we intended to study the impact of political orientation. While not directly available in SIENA, such effects can be implemented as variations of the existing "distance 2" effects, so called as they take place along indirect connections among two nodes in the board mode *via* a node in the director mode. We implemented in particular a distance 2 similarity effect[5], `simD2`, which varies between 0 (for interlocks connecting two boards with maximum covariate difference) and 1 (for identical covariates). If v_i is the covariate value of i, and the observed range of the covariate is $\Delta_v = \max_{ih} |v_i - v_h|$, then the *similarity* among two nodes i and h in the same mode is $\text{sim}_{ih} = \frac{\Delta_v - |v_i - v_h|}{\Delta_v}$ our `simD2` is defined as:

$$s_i(j) = x_{ij} \frac{\sum_{h \neq i} x_{hj} \text{sim}_{ih}}{\sum_{h \neq i} x_{hj}}. \quad (5)$$

In plain words, `simD2` expresses the differential preference for interlocks with similar associations, corresponding to an *homophily* effect in the one-mode projection.

Estimates. As remarked in Vermeulen and Berger [2008], the interlock network forming in Berlin displays a highly hierarchical structure, with two main associations becoming the centers of two distinct "stars" of interlocks with more marginal ones; while the interlocks in Amsterdam seem more haphazard, resulting in a less structured one-mode projection (Fig. 5). As the structure emerging in Berlin displays a strong political polarization, a possible qualitative interpretation of this difference is then that political differences matter more for Turks in Berlin than they do in Amsterdam. This hypothesis can be tested quantitatively using SIENA, and comparing the effect of political similarity on interlock formation in the two towns.

In a first set of experiment (Fig. 5), we tested the four structural effect described above, on both data sets, grouping estimates by four consecutive

[5] A similarly named effect is available in SIENA, but with a different meaning.

years. While the numbers involved are much different (interlocks are a much rarer phenomenon in the voluntary sector), the results follow a similar pattern to that observed by Koskinen and Edling [2012] on much denser interlock networks in the for profit sector. More precisely, the `density` effect is negative, due to the limited number of directors per board, implying that the vast majority of possible ties are absent. The `2-star` effect is mostly negative, suggesting that boards do not actively search to form interlocks: note that, given that `density` acts as a baseline, a negative `2-star` means that associations prefer to enroll an inactive director (forming a simple tie) rather than someone who is already active in another board (forming an interlock). The `3-path` is mostly not significant, so its value should be ignored (i.e., when forming an interlock with another board, its size does not matter): in our case, this effect is small but significantly negative in some of the waves (Berlin 1986-1994; Amsterdam 1998-2003), indicating a preference for smaller boards. `4-cycle` is, instead, significantly positive. In practice this means that, when a simple interlock is already present, then an association will prefer to enroll a director from the connected board, rather than a complete outsider. In Koskinen and Edling [2012], the positive sign of this effect is interpreted as a clue of peer referral.

While we cannot compare the magnitudes of different effects on a certain data set (see Sec 3.1), we can, and did, compare the *same* effect estimated on *different* data sets: in particular, we can check for statistically significant differences among the two data-sets. In this case, a comparison among Amsterdam and Berlin reveals that Turkish associations in Berlin have a stronger negative `2-star` and stronger positive `4-cycle`, suggesting that they form interlocks less easy, but are more prone to reinforcing them when present, compared to Turks in Amsterdam: however, the absolute number of four cycles in Berlin is very small. This difference is reflected in the evolution of these two indicators in the two towns (Figs. 4,5). While not significantly different during the 1980s, both indicators start diverging during the early 1990s: the steeper increase of interlocks in Amsterdam corresponds to a significant difference in the `2-star` effect during this decade. The interpretation of the difference in the `4-cycle` effect is more difficult as these structures are particularly rare in Berlin (Fig. 5).

Is this difference sufficient to explain the structure observed in Berlin? Intuitively, politics must play a role, otherwise the interlocks would *not* follow political alignment. After implementing the `simD2` effect, we could test the impact of similarity among associations, including also a net effect of political orientation (Fig. 7). While `density` and `2-star` remain unaffected, the the `4-cycle` effect keeps the same pattern, but its difference looses significance in most of the waves, confirming that structural effects alone are not sufficient to explain this data: as the vast majority of four cycles links politically homogeneous organizations (see Fig. 5), adding this covariate effect renders the structural one superfluous. Ideology by itself is also mostly not significant, except in Berlin during 1985-1992, indicating a greater activity of right-wing associations in recruiting directors. The political affinity among different associations (`ideology simD2`) is instead relevant. It is mostly significant, and positive, in both towns. This is confirmed by grouping the interlocks according to the similarity of the connected associations, using different gray levels in Fig. 4: we can remark that political polarization is very strong in both cities, as the vast majority of interlocks connect associations from the same political side. Regarding significant differences, we can identify two periods where the similarity effect is significantly lower in Amsterdam, in the early and late 90's. This corresponds in Figure 4 to periods with an increasing trend of politically heterogeneous interlocks. A more thorough interpretation of the results will be required to relate significant variations in the effects to historical events which may have affected the associations.

5 Conclusions

Our results are still preliminary, however they already highlight the importance of political homophily, and allow to describe the difference among the two communities in quantitative terms. In this sense, the `2-star` effect seems particularly relevant.

To complete the implementation of Koskinen and Edling [2012], we still need to distinguish among *creation* and *endowment* effects, a feature which is already present in SIENA, but has been modified in their work, in order to deal with the particular unbalance of interlocking directorates, characterized by a large number of nodes in the director mode.

We will also consider additional effects, aimed at explaining the hierarchical structures observed in Berlin: in particular, we will implement the alternative clustering coefficient of Opsahl [2011], as we expect clustering to be one of the potential indicators of social capital.

Other possible modifications that we intend to implement include extending the existing mechanisms of node set composition change Huisman and Snijders [2003] to two mode data; and a more realistic consensual model of tie formation, in which directors can decide to leave the boards, such as currently available for one-mode networks Ripley et al. [2012].

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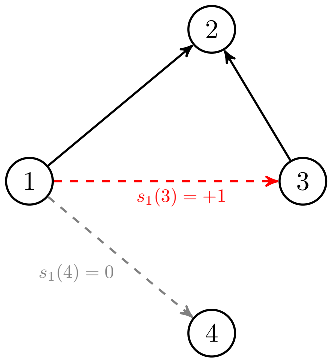


Figure 1: A simple example of a SIENA effect, `transitiveTriplets`, evaluated as $s_i(j) = x_{i,j} \sum_h x_{i,h} x_{j,h}$, which is 1 for links that close a triangle, 0 otherwise.

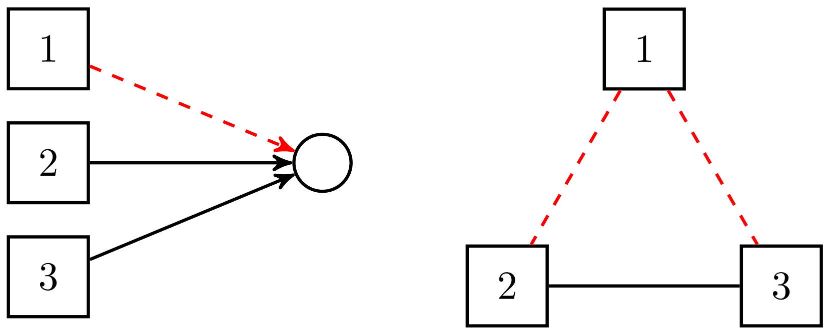
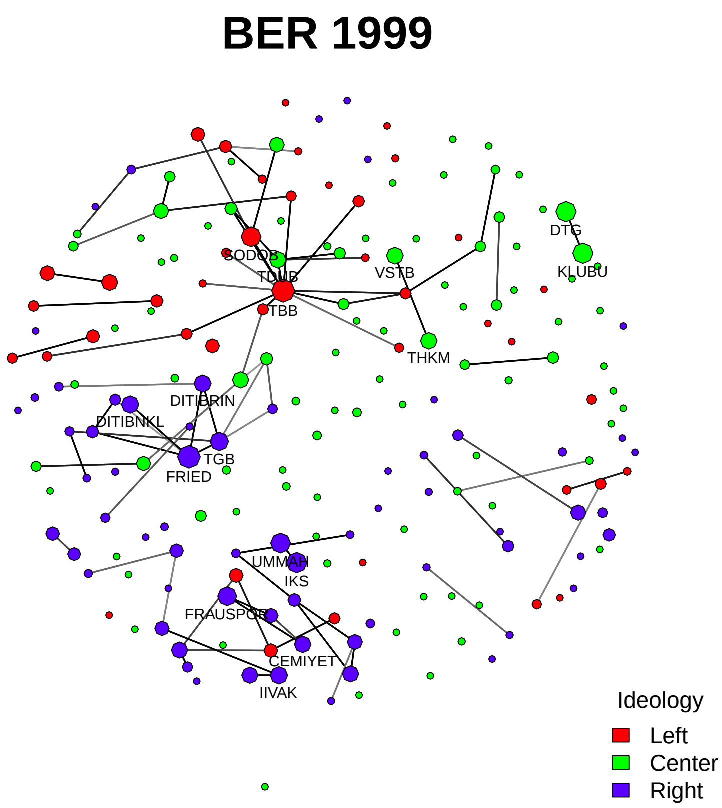


Figure 2: An illustration of the issue with projections. Adding a single link to a node of degree k in the second mode of the two-mode network (left) produces k additional links in the one-mode projection on the first mode (right). Therefore, a node with degree k in the two-mode network will correspond to $\binom{k}{2}$ ties in the projection onto the other mode.



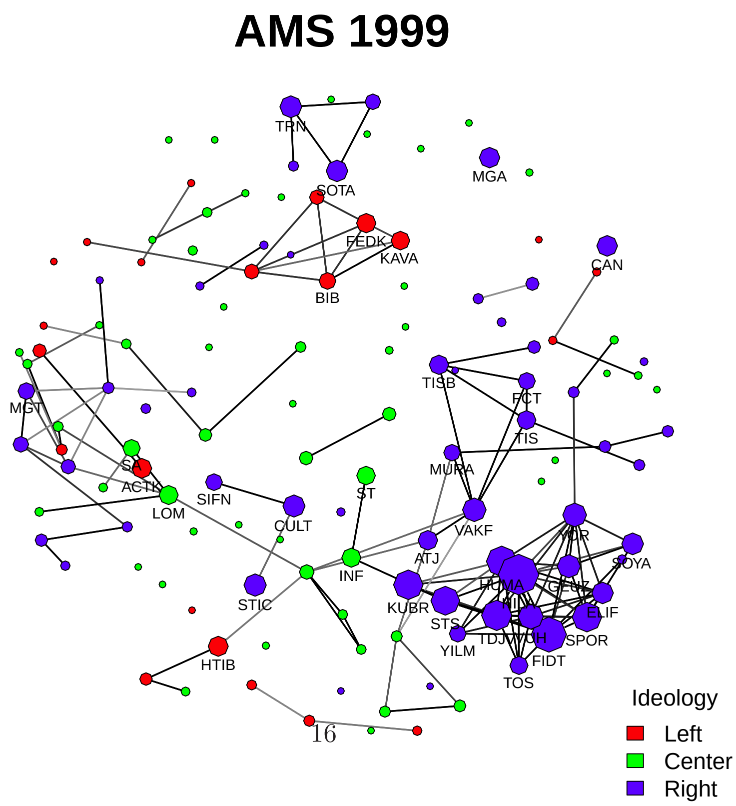


Figure 3: Interlocks in Amsterdam and Berlin during the 90's

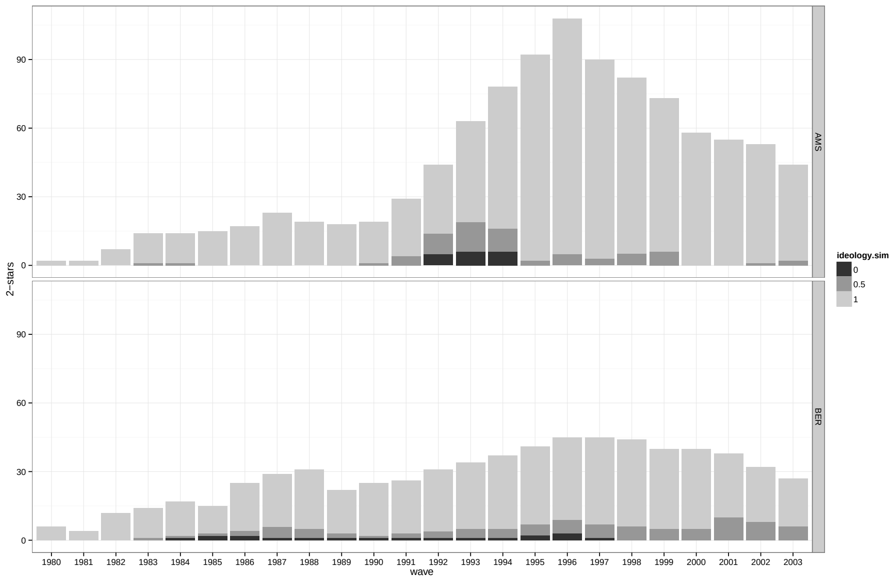


Figure 4: Simple interlocks (`2-star`), per year, in Amsterdam (AMS) and Berlin (BER). Gray levels indicate the similarity of the interlocked organizations (1 left/left or right/right, 0.5 center/left or center/right, 0 left/right). While interlocks seem easier in Amsterdam, both places are characterized by a strong tendency to homophily.

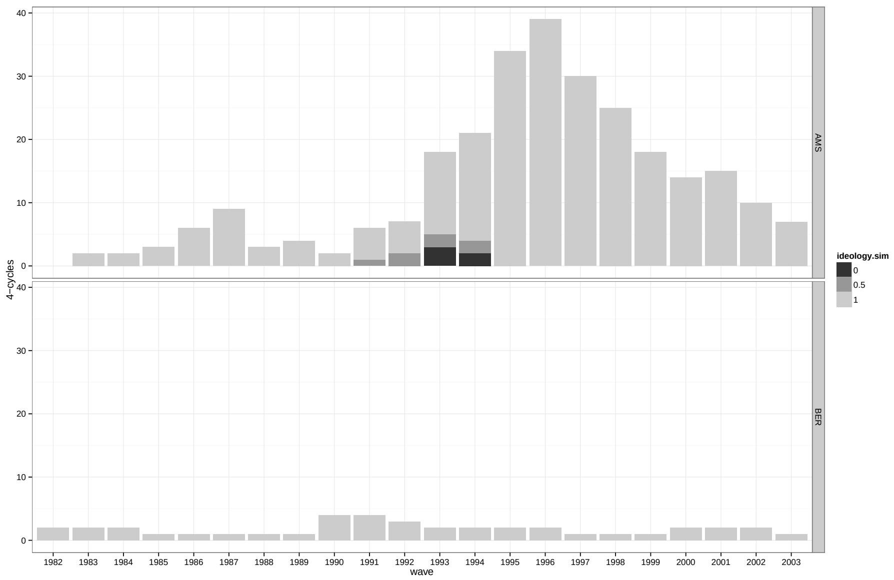


Figure 5: Double interlocks (`4-cycle`), per year, in Amsterdam (AMS) and Berlin (BER). Gray levels indicate the similarity of the interlocked organizations.

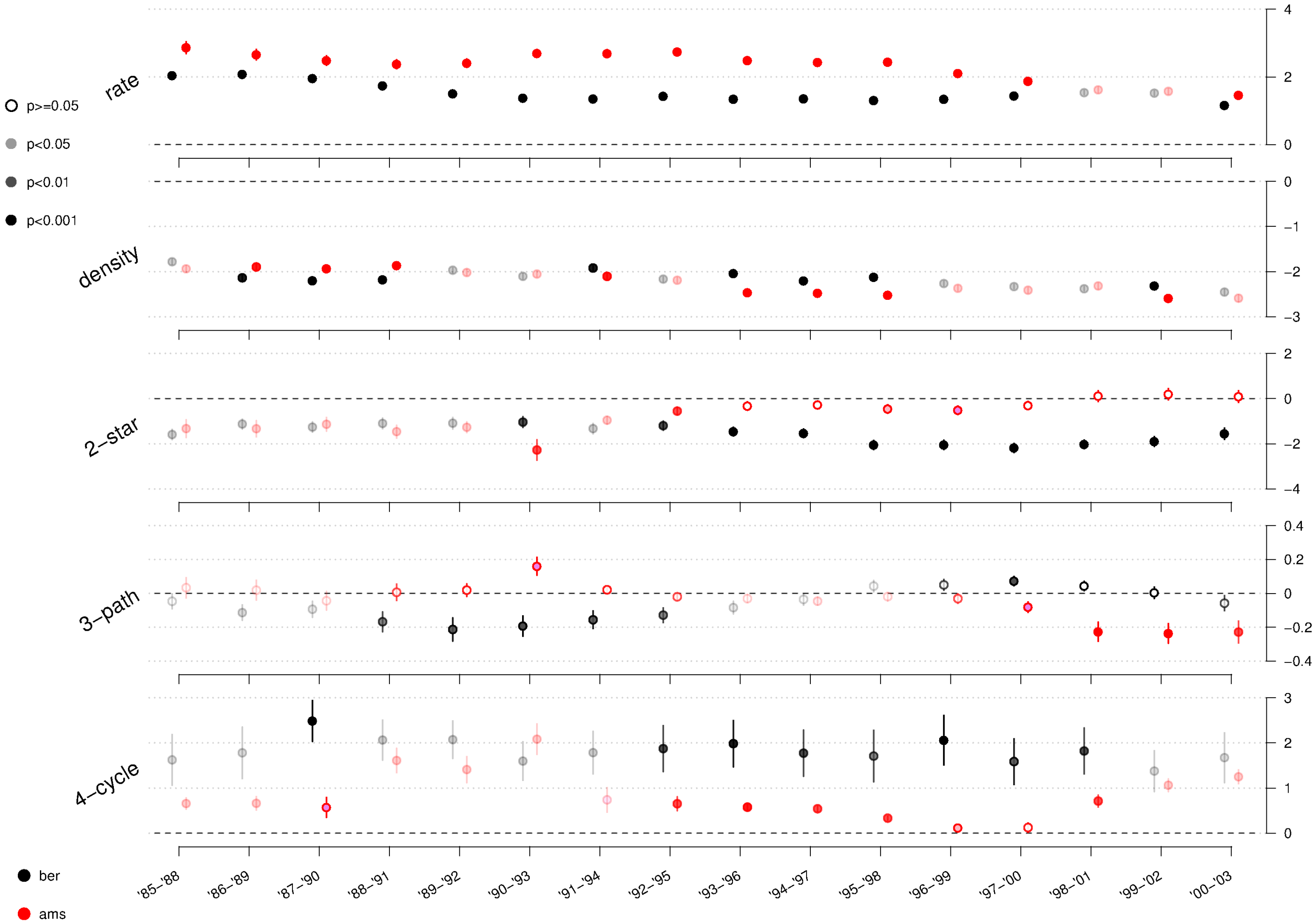


Figure 6: SIENA estimates, structural effects only. Each horizontal section corresponds to an effect. Ticks on the horizontal axes correspond to four consecutive years of data. For each effect, at each year, two circles are plotted, indicating the estimated values for Berlin (left, black), and Amsterdam (right, red). Full circles indicate significant results (based on *p*-values, see legend at upper left), while empty circles are not significant. Vertical segments represent the standard deviation of each estimate. Significant difference among the two towns is instead highlighted using a transparent tint effect where the difference is not significant.

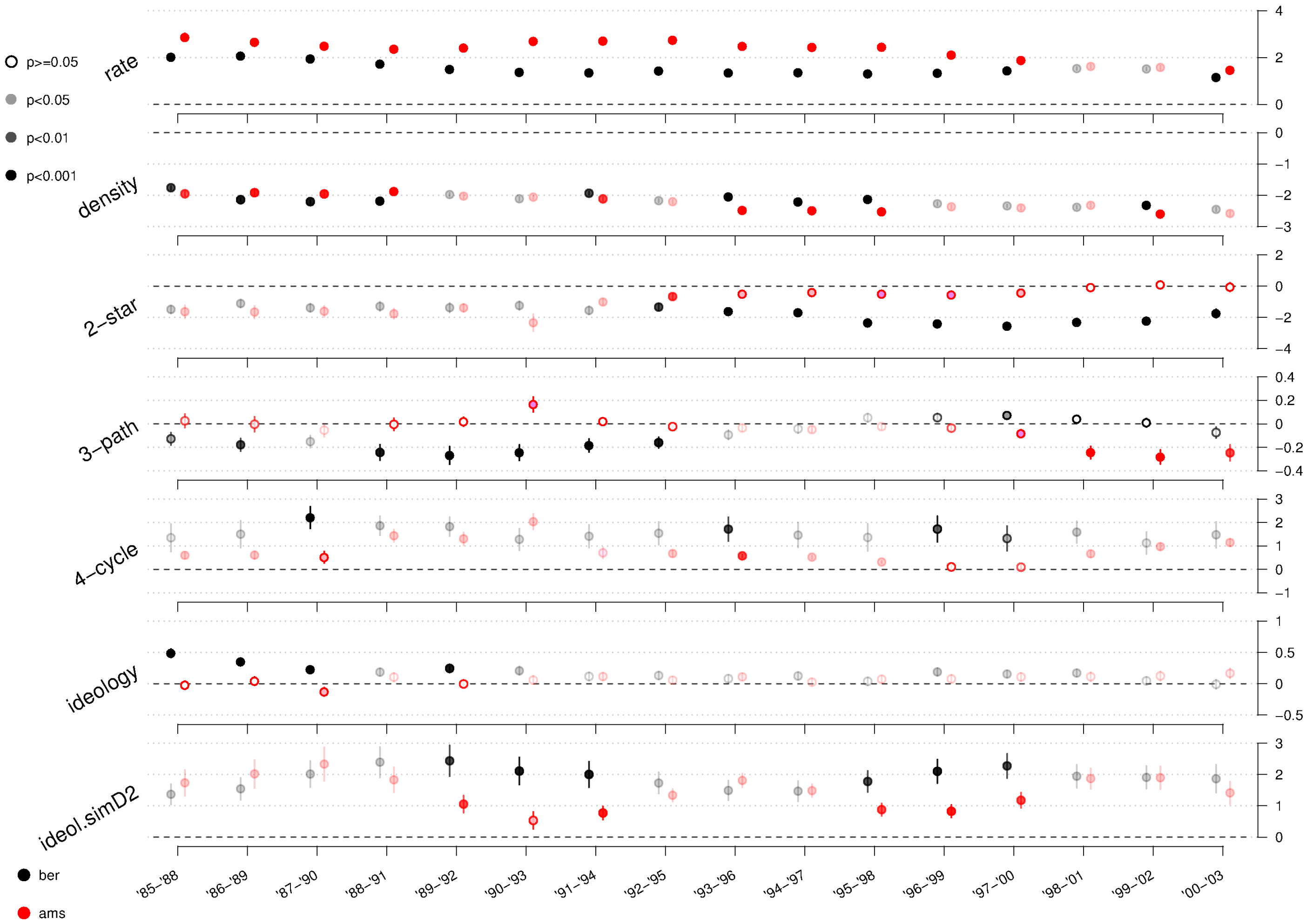


Figure 7: SIENA estimates, including covariates. See previous figure for a legend. The main significant differences can be observed in `2-star` (1990s), `3-path` (1987-1994), and ideology similarity (`simD2`) in two distinct periods (1990s).