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Understanding evolving communities in transnational board interlock networks

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The network structure of the corporate elite is well studied through board interlocks: the sharing of common directors between companies. Corporate networks, where nodes are companies and lines represent interlocks, model how corporations and the individuals therein exert power over others, gain access to information and in general interact within the global economy. Exploring corporate network structures using network analysis techniques has greatly improved our understanding of the global corporate system [1], [2], [3], [4]. Network studies have amongst others aided in unraveling the spread of corporate practice [5], the formation of a corporate elite [6], [1], and the formation of business groups and elite transnationalization [2].

Previous work has applied community detection algorithm to the board interlocks between countries [2] and cities [7]. In these networks, the nodes are countries or cities, with ties formed by board interlocks between directorates of companies in both countries. The community structure of the network is often interpreted based on data attributes, such as geographical layout, to reveal insights on the organization of the global corporate elite. In this work, we extend on this line of research by studying the evolving board interlock network over time and the geographical patterns therein.

As a generic data-driven method, community detection can give new insights in the meso-scale structure of a network. However, there are some challenges with the most commonly applied algorithms for community detection in the social sciences. In particular, the fast and widely used Louvain method for community detection [8] has a few drawbacks. The Louvain method is a heuristic search algorithm, that aims to find a partition that maximizes *modularity*. As with any heuristic optimization algorithm, Louvain might not give an unique optimal answer. It usually finds a local maximum, and in general there are multiple different solutions that have a modularity very close to the theoretical optimum [9]. This can become problematic when drawing conclusions about the domain from the resulting partition, especially if we compare partitions in different snapshots of the network over time (see figure 1). Since there are various valid and near-optimal groupings of a static network into communities, it is difficult for a domain scientist to differentiate between inherent instability of the static community structure and an actual significant change in the network's structure and the observed community composition.

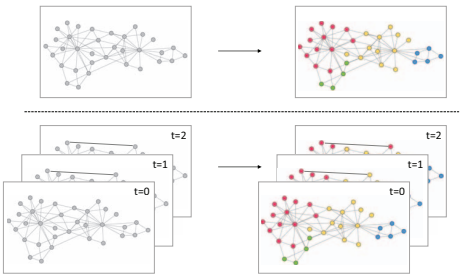

Fig. 1. Community detection on static (top) and dynamic (bottom) networks.

Despite ongoing debates on the usefulness of modularity as a quality measure for community detection [10], we will use it as a starting point in this work due to its wide adoption in the social sciences. Our approach, however, is equally applicable to other non-deterministic community detection methods. We introduce methods to determine and explain the stability of modularity optimization. The search landscape of the Louvain algorithm is investigated, by running the algorithm a substantial number of times (a compute-intensive process), allowing us to quantify the stability of each node's community assignment. We look at the distribution of modularity over the solutions and take into account all partitions with a near-optimal modularity value to determine the stability of edges within and between communities. In the dynamic context, we can then report per node that shifted from one community to the other, whether it was already unstable in the static snapshot, or truly shifted as a result of a significant network community structure change.

We apply the proposed method on the evolving board-interlock network over time, and relate the most significant changes in communities to other attributes, such as geographical location, allowing us to study the dynamics of the global corporate elite structure. Analysis of the evolving global corporate network benefits the debates on globalization and the balance of power between west and east, for example enabling a quantification of the gradual integration of new corporate powers such as China [11]. We show that the proposed method eases interpretation of community detection, and is thus more widely applicable to other domains that use network analysis.

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