The importance of centrality in Victorian Britain

Research question

Does there exist a relationship between the centrality of a firm—as measured by its directorate—and the firms economic performance?

Within the last century institutions have been constructed to discourage overlapping and interlocked directorates on anti–competitive grounds. It is assumed that firms can take advantage of shared information, vested interests, and coalition power through an overlapping directorate and shared voting rights in multiple firms. The presumed exploitation of power was the focus of discussion in the *Money Trust Inquiry* in New York City in 1912/1913. Subsequent policy was created that discouraged overlap. However, during the inquiry many directors and writers claimed that the amount and exploitation of power was being over exaggerated.

Such a phenomena should transcend to all directorate networks. Moreover, directorial overlap, interlock, and power can be studied in terms of a network, thus providing grounds for our research question. Is there indeed a relationship between the performance of firms and how connected their directorate are?

Methodology

Much focus in network science is in developing a set of statistical tools that identify and measure the importance—or *centrality*—of nodes within a given network. These measures are rarely motivated from empirical problems, but instead are constructed to be as general as possible. Consequentially the application of centrality measures tends to be over-simplistic and arbitrary. Nodes that appear to be 'central' by some measure may have no relationship to the importance of the node by some other definable criteria. Moreover, if an important node does have a high centrality the relationship may be spurious.

The β-measure

Due to the potential obfuscating nature of off-the-shelf centrality measures we develop and test our own measure of a nodes centrality. The initial foundation for the bespoke measure is the β-measure, which provides a score for a node based on the nodes outgoing connections, and the incoming connections of all nodes that it points to[1]. This measure is the only axiomatic measure of node centrality to be created but as of now lacks any direct

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[1]The β-measure is related to *PageRank*, Google's algorithm for measuring the relative importance of websites.

application. We suggest, however, that the measure can be used as a proxy for identifying the "influence" of a director in a directorate (bipartite) graph, where a node set can be partitioned into a set of directors and a set of firms.

The β-score of a director measures two aspects: the first is the number of firms that the director is a member of; and the second is the number of directors in each firm that the director is a member of. An assumption must be placed suggesting that a single director has more influence in a firm with fewer directors than in a firm with a greater number of directors; *prima facie* this seems like quite a weak assumption. In fact, depending on the data, we could weaken the assumption further by accurately measuring the influence of each director with regards their voting rights. For directorate networks the β of each individual director is then given as a proportion of the value of the companies that they are members of.

The β-measure is extremely simple: the outcome is that the value of all firms is distributed across all directors by their influence. When the β-scores for each director have been calculated the β-scores for each firm can be calculated by summing the β-score's of all directors for each firm and removing its own value. The result of this is a network of firms where the links show how much influence each firm has on each other by way of their overlapping directorate.

Extending the β-measure and addressing problems

To this point we have discussed a simple augmentation of the β-measure to the application of directorate networks. An initial analysis of this measure may be valuable. Indeed, at this point we could assess the relationship between the β-score of a firm and it's performance. Note that any potential endogeneity between these variables is addressed as a firms β-score only assesses its external influence in the network beyond itself—not its own performance.

However, two immediate problems emerge. First, the β-measure treats all firms and all directors as homogeneous. It cannot distinguish between firms and directors that operate in, and therefore straddle, multiple industries. Second, the measure raises the question of 'why history?', indeed the measure could be applied to any time period.

The first problem can be addressed through an extension of the measure that takes into consideration firms and directors that operate in multiple industries. The extension partitions the directorate network into multiple networks—or *dimensions*—defined by the industry in which firms, and therefore its directors, operate. From this separation of the network the centrality measure is run as above: agents receive a higher centrality from being a director in more firms, however an *interaction measure* can also be added which

allows directors to benefit from participating in industries that are related to each other (for example banking and railways). The level of additional benefit is positively correlated with how related the industries are and how much influence the director has in these industries. So, 'why the interaction measure, why do directors receive this benefit?'. The first reason, which is discussed a lot in network science and sociology literature, is the ability to gather *diverse information.* The second related reason, which is less discussed, is *coordination* between industries.

The second problem, 'why history?', can be addressed with reference to the first. Historical directorate networks are more interesting for multiple reasons: (1) There is less complexity, meaning that industries are easily definable and there exists fewer conglomerates that can span multiple industries; (2) There are fewer rules that concern overlapping directorates, meaning that agents are not simply conforming to an institutional way of linking; and (3) It was noted above that directors receive an informational benefit from participating in multiple industries; historical markets may provide more opportunities for informational arbitrage between firms and between industries relative to highly-connected contemporary markets. Historical networks may indeed provide a clearer story and cleaner relationships.

Derived questions

The summary statistics of the network may highlight a lot: (1) What does the structure of the network look like (i.e., is it scale-free, is it a small-world, is it isomorphic)?; (2) How well connected are firms on average? Does this change between industries?; (3) What industry has the most *branching* (i.e., are directors in banking more likely to also have directorships outside of banking)?; (4) Do industries become more intertwined over time and why?; (5) Is influence centralised within a handful of directors, what about between industries?; (6) How does geography play a role?; (7) Do any off-the-shelf centrality measures actually find firms and directors that were important? Why or why not?