Before and After the Financial Crash: The Corporate Network Evolution and Sustainability Implications

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ABSTRACT

The control network structure of transnational corporations (TNC) not only affects global markets, but also holds fundamental implications for policy-making mechanisms underpinning the sustainable use of environmental resources, and a sustained commitment to human welfare and civil liberties. Previous analysis of the TNC network topology has revealed a giant bow-tie structure controlled by a close-knit financial core. However, to our knowledge, little research has been done on (a) how this structure has evolved over time – i.e. before and after the financial crash in 2008; and (b) the implication, not so much on global financial and social 'stability', but on long-term environmental and societal sustainability. Our research uses computational data-driven methods to investigate how the TNC network has evolved in the last 10 years and reflect on its long-term implications.

BACKGROUND

Vitali's et al. work [8] is one of the first to provide a large-scale quantitative evidence to *"the common intuition"* that the global economy is in the hands of very few powerful transnational corporations (TNCs). Their investigation found that the TNC network topology is of a giant bow-tie structure controlled by a small highly connected economic *"super-entity"* [8] and Figure 1 in *Appendix 2*. Specifically, little more than 0.3% of all the TNCs hold 40% of the control over the TNCs economic value worldwide, moreover, 75% of the core are financial intermediaries. The bow-tie network architecture is a relatively recent concept that refers to recurrent control structures underlying complex systems including technological (e.g. the WWW) and biological (e.g. the metabolic network) [4]. These structures seem capable of balancing efficiency, robustness and evolution, but they do also suffer from fragility [8].

Vitali et al. use pre-crash data (Orbis 2007) in their study, and to our knowledge, post-crash data has yet to be used. This begs the question of what happened to the TNCs control structure after the 2008 financial crash i.e. where stability can be noted, and where change [2]. A popular belief is that nothing changed after the crash: a few financial institutions may have disappeared, but overall the banks were bailed out, large bonuses are still handed out to TNCs CEOs, whilst taxpayers and, most directly, subprime borrowers are still paying for a crash over which they had *no control*.

Can this intuition be supported with quantitative evidence? Moreover, can *"leverage points for sustainability"*[5] be identified within these control structures? For example, how, and where in the control network, policy interventions can be best targeted to foster, not merely financial and social *stability* [7], but a sustained commitment to long-term environmental and societal *sustainability* [6]? In other words, can control be matched with accountability?

APPROACH

One of our research objectives is to repeat Vitali et al. study [8] with Orbis latest dataset (2017). Awaiting for Orbis dataset access, we carry out a pilot study using publicly available data and clustering algorithms. Our main source is the Yago ontology [1]. Yago contains company ownership information included in Wikipedia and in *Appendix 1* we discuss in detail our data collection process and how we arrive at a graph structure that includes the companies as nodes and the ownership information as edges between them.

Our analysis is two-fold. From one hand, we are interested in finding strong clusters of companies and for each cluster the company that is the most representative (or exemplar). For this, we plan to use the Affinity Propagation Clustering algorithm, proposed by Frey and Dueck [3]. This algorithm automatically discovers the number of strong components i.e. clusters and identifies each cluster exemplar node.

We will also investigate how clusters of companies, evolve over time. Our hypothesis is that companies' ownerships remain unchanged over time. Using the techniques proposed by Bansal et al., [2], we intend to study the stability of company clusters over time and especially compare the clusters before and after the financial crash of 2008. Our data collection procedure is further discussed in *Appendix 1*.

ICT4S INTERACTIONS

Our ICT4S poster session objectives are threefold: 1) discuss emerging results from a preliminary pilot study using an open source knowledge base Yago. 2) Engage in conversation with ICT4S delegates by sharing, where possible, research data and its visual or physical representations – we may need a table. 3) Identify opportunities for discussing the topic with other disciplines specialists, i.e. from life sciences, law, and system thinking to outline future research directions.

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APPENDIX 1 - Pilot Data Collection

The goal of this preliminary study was to extract data related to major transnational corporations and their subsidiaries in order to gain knowledge of economic control on a global scale following the global recession of 2008. Data collection began by researching available databases that provided the desired knowledge relevant to the present project.

YAGO

Yago [1] is an open source, semantic web database that extracts information from sources such as Wikipedia, Wordnet and GeoNames. It is an ontology with more than 10 million entities and an evaluated accuracy of 95%. Yago's ontology establishes relationships (properties) between its entities, which is either a subject or an object. In its entirety, Yago holds 168GB of storage, however this is partly due to the many languages in which Yago data is offered. For this project, YAGO was downloaded in tsv format files separated into different themes.

Among the available properties in Yago, the "owns" and "rdf:type" relations are the most applicable to this project's objective. The former will show ownership between entities and the latter will help to identify and filter for entities of type organization. As such, YagoFacts was queried to find all entities that showed an "owns" or an "rdf:type" relationship. Once downloaded, a chosen tsv file - YagoFacts.tsv - was uploaded to a SAS server and was queried using SQL. Since many of Yago's tsv files are rather large, it was decided that the remainder of the YAGO files would first be analyzed through Window's command prompt using the following script:

```
FINDSTR /M "<string>" filename.tsv
```

This analysis examined each yago file and returned the files that contained the desired strings. In this case the strings searched for were: the relationships "<owns>" and "<rdf:type>" and the object "<wordnet_organization_108008335>" and "<wordnet_company_108058098>". Following this step, PostgreSQL (Postgres) was used to query the selected files in place of the previously used SAS server. Using Window's command prompt a table was created in Postgres that included the files that were identified by the 'FINDSTR' command previously mentioned. With the significant entities in place, the table was queried to find organizations and their subsidiaries within the Yago Database.

Graph Database - Neo4j

A graph database uses a graph model to store data and has a primary focus on relationships between entities or nodes. As the current project relies heavily on the relationship between the entities within the above data, storing it in a graph database was the most logical course of action.

Neo4j is an open source graph database management system that uses the property graph model to structure and store data. Neo4j also employs a query language to manipulate data that is similar to SQL called Cypher. Cypher is a fairly simple and easy to learn language. In order to load the Yago data in Neo4j each entity within their attribute (subject, object and property) was treated as separately and loaded separately into Neo4j. The following script was used to load the data:

```
LOAD
   CSV WITH HEADERS FROM "file:///path.tsv" AS row
   CREATE (:Subject {Subject: row.Subject});
```

Once the nodes were created, the relationship "owns" that joins both subject and object nodes was also created using the following script:

```
LOAD
   CSV WITH HEADERS FROM "file:///path.tsv" AS row
   MATCH (subject:Subject {Subject: row.Subject})
   MATCH (object:Object {Object: row.Object})
   MERGE (subject)-[:Owns]->(object);
```

With the relevant Yago data stored in Neo4j, Cypher was used to query the data and readily returned the graphs with the stored Yago relationships.

APPENDIX 2 - Network Topology

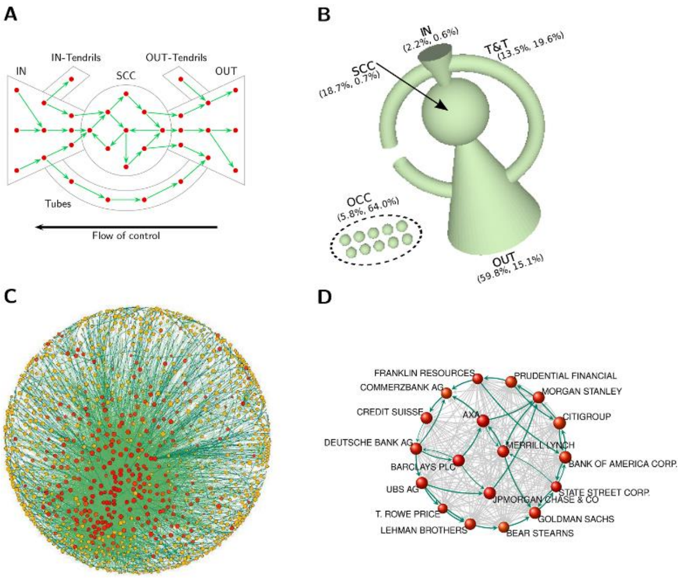

Fig 1 Network Topology: by Vitali S, Glattfelder J, Battiston S [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

Description of Figure 1 from [8]:

"(A) A bow-tie consists of in-section (IN), out-section (OUT), strongly connected component or core (SCC), and tubes and tendrils (T&T). (B) Bow-tie structure of the largest connected component (LCC) and other connected components (OCC). Each section volume scales logarithmically with the share of its TNCs operating revenue. In parenthesis, percentage of operating revenue and number of TNCs, cfr. Table 1. (C) SCC layout of the SCC (1318 nodes and 12191 links). Node size scales logarithmically with operation revenue, node color with network control (from yellow to red). Link color scales with weight. (D) Zoom on some major TNCs in the financial sector. Some cycles are highlighted."

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