The network of global corporate control

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Abstract

The structure of the control network of transnational corporations affects global market competition and financial stability. So far, only small national samples were studied and there was no appropriate methodology to assess control globally. We present the first investigation of the architecture of the international ownership network, along with the computation of the control held by each global player. We find that transnational corporations form a giant bow-tie structure and that a large portion of control flows to a small tightly-knit core of financial institutions. This core can be seen as an economic "super-entity" that raises new important issues both for researchers and policy makers.

Introduction

A common intuition among scholars and in the media sees the global economy as being dominated by a handful of powerful transnational corporations (TNCs). However, this has not been confirmed or rejected with explicit numbers. A quantitative investigation is not a trivial task because firms may exert control over other firms via a web of direct and indirect ownership relations which extends over many countries. Therefore, a complex network analysis [1] is needed in order to uncover the structure of control and its implications. Recently, economic networks have attracted growing attention [2], e.g., networks of trade [3], products [4], credit [5, 6], stock prices [7] and boards of directors [8, 9]. This literature has also analyzed ownership networks [10, 11], but has neglected the structure of control at a global level. Even the corporate governance literature has only studied small national business groups [12]. Certainly, it is intuitive that every large corporation has a pyramid of subsidiaries below and a number of shareholders above. However, economic theory does not offer models that predict how TNCs globally connect to each other. Three alternative hypotheses can be formulated. TNCs may remain isolated, cluster in separated coalitions, or form a giant connected component, possibly with a core-periphery structure. So far, this issue has remained unaddressed, notwithstanding its important implications for policy making. Indeed, mutual ownership relations among firms within the same sector can, in some cases, jeopardize market competition [13, 14]. Moreover, linkages among financial institutions have been recognized to have ambiguous effects on their financial fragility [15, 16]. Verifying to

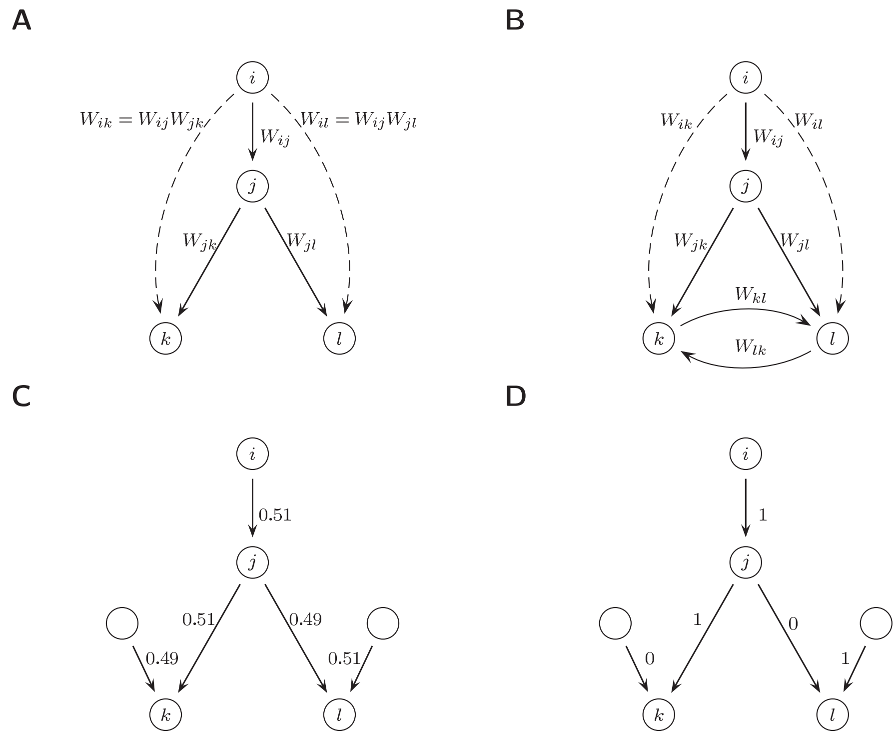

Figure 1: **Ownership and Control.** (**A&B**) Direct and indirect ownership. (A) Firm i has W_{ij} percent of direct ownership in firm j. Through j, it has also an indirect ownership in k and l. (B) With cycles one has to take into account the recursive paths, see SI Appendix, Sec. 3.1. (**C&D**) Threshold model. (C) Percentages of ownership are indicated along the links. (D) If a shareholder has ownership exceeding a threshold (e.g. 50%), it has full control (100%) and the others have none (0%). More conservative model of control are also considered see SI Appendix, Sec. 3.1.

what extent these implications hold true in the global economy is *per se* an unexplored field of research and is beyond the scope of this article. However, a necessary precondition to such investigations is to uncover the worldwide structure of corporate control. This was never performed before and it is the aim of the present work.

Methods

Ownership refers to a person or a firm owning another firm entirely or partially. Let W denote the ownership matrix, where the component $W_{ij} \in [0, 1]$ is the percentage of ownership that the owner (or *shareholder*) i holds in firm j. This corresponds to a directed weighted graph with firms represented as nodes and ownership ties as links. If, in turn, firm j owns W_{jl} shares of firm l, then firm i has an *indirect ownership* of firm l (Fig. 1 A). In the simplest case, this amounts trivially to the product of the shares of direct ownership $W_{ij}W_{jl}$. If we now consider the economic value v of firms (e.g., operating revenue in USD), an amount $W_{ij}v_j$ is associated to i in the direct case, and $W_{ij}W_{jl}v_l$ in the indirect case. This computation can be extended to a generic graph, with some important caveats [17, SI Appendix, Secs. 3.1 and 3.2].

Each shareholder has the right to a fraction of the firm revenue (dividend) and to a voice in the decision making process (e.g., voting rights at the shareholder meetings). Thus the larger the ownership share W_{ij} in a firm, the larger is the associated *control* over it, denoted as C_{ij}. Intuitively, control corresponds to the chances of seeing one's own interest prevailing in the business strategy of the firm. Control C_{ij} is usually computed from ownership W_{ij} with a simple threshold rule: the majority shareholder has full control. In the example of Fig. 1 C, D, this yields $C_{ij}v_j = 1\, v_j$ in the direct case and $C_{ij}C_{jl}v_l = 0$ in the indirect case. As a robustness check, we tested also more conservative models where minorities keep some control (see SI Appendix, Sec. 3.1). In analogy to ownership, the extension to a generic graph is the notion of *network control*: $c_i^{\text{net}} = \sum_j C_{ij}v_j + \sum_j C_{ij}c_j^{\text{net}}$. This sums up the value controlled by i through its shares in j, plus the value controlled indirectly via the network control of j. Thus, network control has the meaning of the total amount of economic value over which i has an influence (e.g. $c_i^{\text{net}} = v_j + v_k$ in Fig. 1 D).

Because of indirect links, control flows upstream from many firms and can result in some shareholders becoming very powerful. However, especially in graphs with many cycles (see Figs. 1 B and S4), the computation of c^{net}, in the basic formulation detailed above, severely overestimates the control assigned to actors in two cases: firms that are part of cycles (or cross-shareholding structures), and shareholders that are upstream of these structures. An illustration of the problem on a simple network example, together with the details of the method are provided in SI Appendix, Secs. 3.2 – 3.4. A partial solution for small networks was provided in [18]. Previous work on large control networks used a different network construction method and neglected this issue entirely [11, SI Appendix, Secs. 2 and 3.5]. In this paper, by building on [11], we develop a new methodology to overcome the problem of control overestimation, which can be employed to compute control in large networks.

Results

We start from a list of 43060 TNCs identified according to the OECD definition, taken from a sample of about 30 million economic actors contained in the Orbis 2007 database (see SI Appendix, Sec. 2). We then apply a recursive search (Fig. S1 and SI Appendix, Sec. 2) which singles out, for the first time to our knowledge, the network of all the ownership pathways originating from and pointing to TNCs (Fig. S2). The resulting TNC network includes 600508 nodes and 1006987 ownership ties.

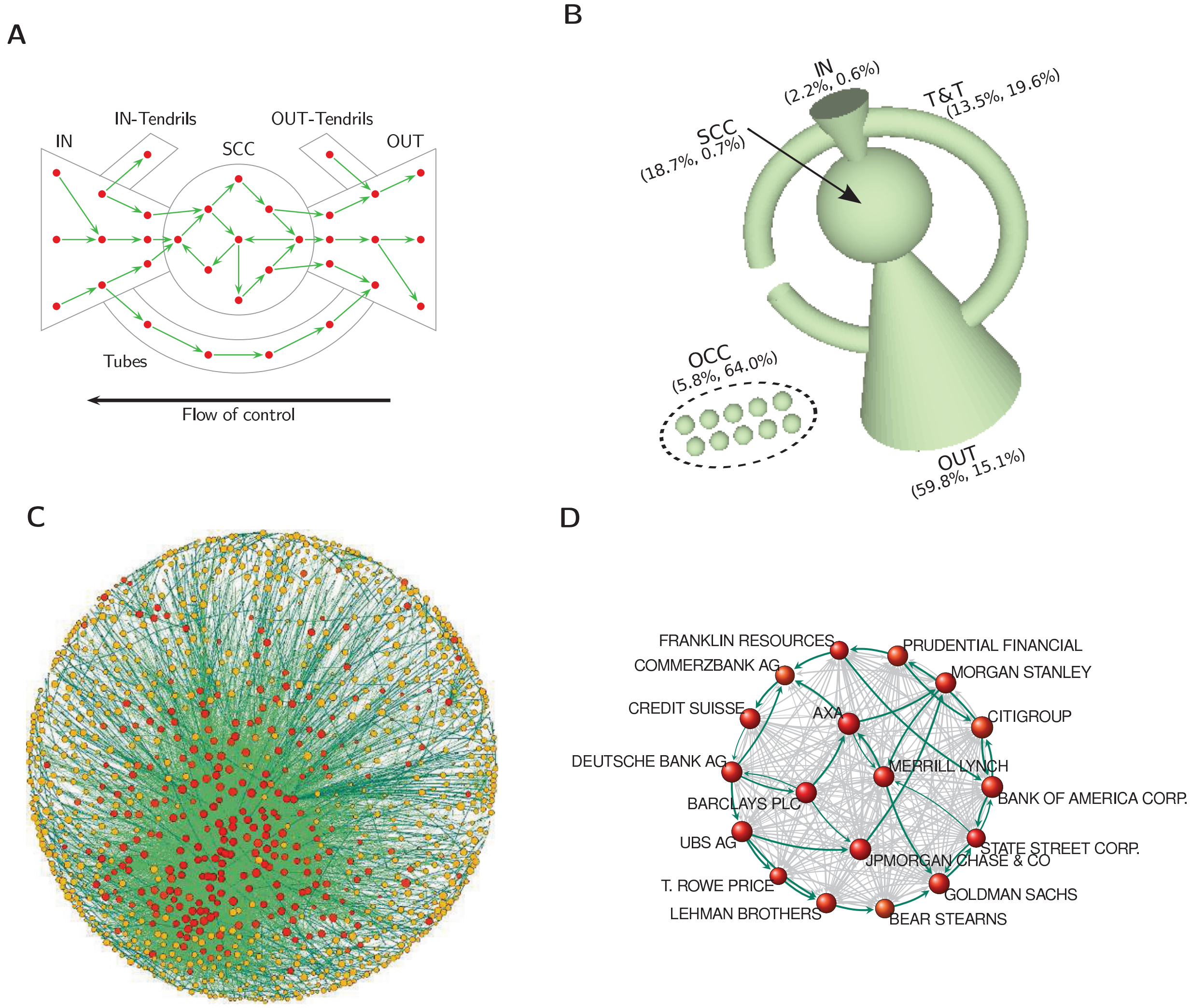

Figure 2: **Network topology.** (**A**) A bow-tie consists of in-section (IN), out-section (OUT), strongly connected component or core (SCC), and tubes and tendrils (T&T). (**B**) Bow-tie structure of the largest connected component (LCC) and other connected components (OCC). Each section volume scales 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.

Notice that this data set fundamentally differs from the ones analysed in [11] (which considered only listed companies in separate countries and their direct shareholders). Here we are interested

Table 1: **Bow-tie statistics.** Percentage of total TNC operating revenue (OR) and number (#) of nodes in the sections of the bow-tie (acronyms are in Fig. 2). Economic actors types are: shareholders (SH), participated companies (PC).

	TNC (#)	SH (#)	PC (#)	OR (%)
LCC	15491	47819	399696	94.17
IN	282	5205	129	2.18
SCC	295	0	1023	18.68
OUT	6488	0	318073	59.85
T&T	8426	42614	80471	13.46
OCC	27569	29637	80296	5.83

in the true global ownership network and many TNCs are not listed companies (see also SI Appendix, Sec. 2).

Network Topology

The computation of control requires a prior analysis of the topology. In terms of connectivity, the network consists of many small connected components, but the largest one (3/4 of all nodes) contains all the top TNCs by economic value, accounting for 94.2% of the total TNC operating revenue (Tbl. 1). Besides the usual network statistics (Figs. S5, S6), two topological properties are the most relevant to the focus of this work. The first is the abundance of cycles of length two (mutual cross-shareholdings) or greater (Fig. S7 and SI Appendix, Sec. 7), which are well studied motifs in corporate governance [19]. A generalization is a *strongly connected component* (SCC), i.e., a set of firms in which every member owns directly and/or indirectly shares in every other member. This kind of structures, so far observed only in small samples, has explanations such as anti-takeover strategies, reduction of transaction costs, risk sharing, increasing trust and groups of interest [20]. No matter its origin, however, it weakens market competition [13, 14]. The second characteristics is that the largest connect component contains only one dominant strongly connected component (1347 nodes). Thus, similar to the WWW, the TNC network has a *bow-tie* structure [21] (see Fig. 2 A and SI Appendix, Sec. 6). Its peculiarity is that the strongly connected component, or *core*, is very small compared to the other sections of the bow-tie, and that the out-section is significantly larger than the in-section and the tubes and tendrils (Fig. 2 B and Tbl. 1). The core is also very densely connected, with members having, on average, ties to 20 other members (Fig. 2 C, D). As a result, about 3/4 of the ownership of firms in the core remains in the hands of firms of the core itself. In other words, this is a tightly-knit group of corporations that cumulatively hold the majority share of each other.

Notice that the cross-country analysis of [11] found that only a few of the national ownership networks are bow-ties, and, importantly, for the Anglo-Saxon countries, the main strongly connected components are big compared to the network size.

Concentration of Control

The topological analysis carried out so far does not consider the diverse economic value of firms. We thus compute the network control that economic actors (including TNCs) gain over the TNCs' value (operating revenue) and we address the question of how much this control is concentrated and who are the top control holders. See Fig. S3 for the distribution of control and operating revenue.

It should be noticed that, although scholars have long measured the concentration of wealth and income [22], there is no prior quantitative estimation for control. Constructing a Lorenz-like curve (Fig. 3) allows one to identify the fraction η^* of top holders holding cumulatively 80% of the total network control. Thus, the smaller this fraction, the higher the concentration. In principle, one could expect inequality of control to be comparable to inequality of income across households and firms, since shares of most corporations are publicly accessible in stock markets. In contrast, we find that only 737 top holders accumulate 80% of the control over the value of all TNCs (see also the list of the top 50 holders in Tbl. S1 of SI Appendix, Sec. 8.3). The corresponding level of concentration is $\eta_1^* = 0.61\%$, to be compared with $\eta_2^* = 4.35\%$ for operating revenue. Other sensible comparisons include: income distribution in developed countries with $\eta_3^* \sim 5\% - 10\%$ [22] and corporate revenue in Fortune1000 ($\eta_4^* \sim 30\%$ in 2009). This means that network control is much more unequally distributed than wealth. In particular, the top ranked actors hold a control ten times bigger than what could be expected based on their wealth. The results are robust with respect to the models used to estimate control, see Fig. 3 and Tbls. S2, S3.

Discussion

The fact that control is highly concentrated in the hands of few top holders does not determine if and how they are interconnected. It is only by combining topology with control ranking that we obtain a full characterization of the structure of control. A first question we are now able to answer is where the top actors are located in the bow-tie. As the reader may by now suspect, powerful actors tend to belong to the core. In fact, the location of a TNC in the network does matter. For instance, a randomly chosen TNC in the core has about 50% chance of also being among the top holders, compared to, e.g., 6% for the in-section (Tbl. S4). A second question concerns what share of total control each component of the bow-tie holds. We find that, despite its small size, the core holds collectively a large fraction of the total network control. In detail, nearly 4/10 of the control over the economic value of TNCs in the world is held, via a complicated web of ownership relations, by a group of 147 TNCs in the core, which has almost full control over itself. The top holders within the core can thus be thought of as an economic "super-entity" in the global network of corporations. A relevant additional fact at this point is that 3/4 of the core are financial intermediaries. Fig. 2 D shows a small subset of well-known financial players and their links, providing an idea of the level of entanglement of the entire core.