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On the topological structure of multinationals network☆

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HIGHLIGHTS

- The underlying countries network of French multinationals' foreign affiliates is revealed and studied.
- Vertex (host countries) and dyad (investing firms) specific metrics are in line with previous findings on foreign direct investments.
- Network-wide metrics bring an original insight to the topic.
- The change of the network structure over 7 years shows a decentralization trend.
- Firm heterogeneity seems to matter in network building, with least productive firms following more common internationalization strategies.

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ABSTRACT

This paper uses a weighted network analysis to examine the structure of multinationals' implantation countries network. Based on French firm-level dataset of multinational enterprises (MNEs) the network analysis provides information on each country position in the network and in internationalization strategies of French MNEs through connectivity preferences among the nodes. The paper also details network-wide features and their recent evolution toward a more decentralized structure. While much has been said on international trade network, this paper shows that multinational firms' studies would also benefit from network analysis, notably by investigating the sensitivity of the network construction to firm heterogeneity.

1. Introduction

Since the early 2000s an increasing number of papers have focused on the empirical examination of economic networks structure. Among them international trade, through the World Trade Web (WTW) analysis, has been one of the first – and probably also one of the most – economic field studied through a network approach. Pioneer works study topological properties of the WTW [1–7]. Then more precise issues were addressed through the network analysis, as the evolution of the WTW structure over time [8], or the sectoral differences in the trade network [9,10]. However, the current globalization is rather driven by Multinational Enterprises (MNEs), Foreign Direct Investments (FDIs) and intra-firm trade than by arm's length trade [11,12]. Surprisingly, only a few works explored the structure of FDI networks of multinational firms. Nonetheless, the high interdependences between related affiliates coordinated by common headquarters, which share capital, workers and technologies besides goods, calls for a network approach to better understand the geographical breakdown of their global structure.

Sgrignoli [13] compares the two network structures of countries bilateral trade flows (WTW) and bilateral Foreign Direct Investment (FDIN), and shows that both share a disassortative pattern and a similar (and very concentrated) strength

☆ The access to the data was carried through the CASD dedicated to researchers authorized by the French *Comité du secret statistique*.

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distribution. However, the bilateral network structure blurs the individual MNEs boundaries. Conversely, focusing on Italian firm FDI network, de Masi et al. [14] build a bipartite network of investing firms and host countries, and alternatively use projection on the "firm space" (resulting in a network of firms, linked according to the common number of countries they have invested in), and more rarely develop the projection on the "country space" (resulting in a network of countries, linked according to the number of firms that are jointly present in both countries), but do not give much information about the latter.

This paper has two premises: first, the recent increase in firm-level data availability, coupled improvement in computability of network analysis through statistical softwares.[1] Second, as noted above, the fact that the international trade networks are now commonly studied, whereas FDIs and more especially multinational firms networks are still to explore. Using firm-level data on French multinationals, this paper aims at revealing the topological structure of the underlying network of MNEs' implantation countries, and properly quantify this properties through vertex-specific, dyad-specific and network-wide measures. Similarly to world trade network, the analysis shows a high centralization degree and a disassortative pattern of the network structure. However, while Fagiolo et al. [8] note that the WTW structure did not change much since the 1980*s*, this paper shows that the MNEs network did evolve more recently toward a decentralized structure. Moreover, further results tend to indicate that firm heterogeneity plays a role in the FDI network building.

The paper is constructed as follows: in Section 2, I detail the network building methodology. Then Section 3 reveals the network's topological structure, and how it evolved over time. Section 4 Insists on the firms internationalization path, and the way the network expands. The following section presents two sub-networks according to firm heterogeneity. Finally, Section 6 concludes.

2. Network building

Based on French firm-level data of foreign affiliates' location, I built a weighted directed network (WDN) of multinational firms, where the nodes are the world's countries. Two countries are linked if they both host an affiliate of the same MNE. The direction of the arcs indicates the chronological sequence of the multinational expansion.[2] Then each arc is weighted corresponding to the number of firms using this country association, in that order, to highlight similar pattern of international expansions of French firms. The resulting network pattern is very close to the one built by de Masi et al. when detailing the projection of their bipartite graph in the subspace of countries (see figure 3, in Ref. [14]), except for the additional direction information.

The data on foreign French affiliates comes from LiFi, a yearly survey run by the French national statistic institute (*INSEE*). It lists the subsidiaries of French firms identified as "head of group". Hence, our network is not only made of directly controlled affiliates, but also of the entities they could themselves own, ensuring a proper vision of the actual network of French multinationals. Only majority-held subsidiaries were considered. Although LiFi design involves threshold values, they are quite low for multinational firms, hence the non-reported firms – if any – may not lead networks large enough to significantly change the identified pattern of MNEs network.[3] Self loops were not considered, ignoring multiple-plants in a given country as the final objective is to study the pattern of country pairing. Also, France is not included in the network as it is the headquarters country of all firm considered. The set of countries is henceforth made of all countries, excluded France and countries without any French affiliate because they are not part the multinationals' network. In 2011 (last year available), the French multinationals' affiliates network counts 167 countries, implying over 27,720 (directed) arcs possibilities, with 2,996 firms and 19,872 subsidiaries composing it.[4] Fig. 1 displays a preview of the network.

3. Topological structure of multinationals network

3.1. Overview

Before examining the connectivity pattern of the network, an overview details the principal destinations of French FDIs, where unsurprisingly the USA stand first with over 12% of French affiliates in our sample. Below, the United Kingdom, Germany and Spain have a similar share of around 6% of French foreign subsidiaries. Concerning the pairs of countries used together, the three main associations in 2011 are Germany–Spain (done by 11.3% of French MNEs in our sample), followed by Italy–Spain (11.0%) and Germany–United Kingdom (10.8%). French firms seem to associate similar and relatively close countries in their international development. Although the USA are the main destination, they do not appear in the main associations of countries. This refers to the connectivity profiles of the USA, which might differ from European countries' one. To further examine this topic, let us introduce some network metrics.

[1] I am especially grateful to Thomas Grund and its nwcommands package for Stata. I also have developed my own Stata packages to compute some additional network metrics (ANND, ANNS, strength centralization, disparity, and weighted clustering coefficient), available on Boston College SSC archive.

[2] Let W be the directed weighted adjacency matrix, and X the undirected weighted matrix. We therefore have $W + W' = X$. The total link between the two countries i and j is the sum of links from i to j and from j to i.

[3] Only firms that fulfill one of the four following criteria are surveyed in LiFi: The participation into other firms outpaces 1.2 million euros; the firms employs at least 500 employees; its turnover is superior to 60 million euros; the firm has been previously identified as "head of group".

[4] As a consequence of the research question, French MNEs with only one foreign affiliates were not included in the designed network, because they do not associate any country pairs.