Network Analysis of the Development Assistance for Health Database

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Abstract

This study investigates the structural evolution of global health financing through official development assistance (ODA) from 1990 to 2022 using a network analytical framework. Utilizing the Development Assistance for Health (DAH) dataset the changes in the behavior and struggles of sources, channels and recipient countries are analyzed. Temporal and thematic multiplex networks illustrate the diversification of aid flows and the growing role of multilateral and non-state actors. While the analysis captures broad historical trends—from post-cold war uncertainty to the "war on terror" and the rise of philanthropic donors—it does not account for the magnitude of financial flows, highlighting a key limitation. Nonetheless, this research demonstrates that network analysis is capable of decoding aid allocation systems and offers a novel perspective on the dynamic architecture of global health funding.

Introduction

Over the last three decades, the character of financing global health within official development aid (ODA) has changed. It has become more pluralistic and inter-governmental institutions like the UN and the World Health Organization (WHO) have become more and more important. But the ODA has already started changing drastically again due to the recent changes in the US politics *(Spillner, 2024; Klickbusch, 2024)*, which affects the global health sector immensely. Therefore, this paper investigates the financing network of global health and its changes over time. To analyze that it uses the Development Assistance for Health (DAH) database from the Institute for Health Metrics and Evaluation (IHME) at the University of Washington. The DAH Database is part of the GHDx, the Global Health Data Exchange and funded by the Bill and Melinda Gates Foundation. The database tracks international disbursements for health from various funding sources to recipient countries and regions. It also keeps track of the channel through which the funding is allocated and on which health focus area the founding is spent. The database contains 456938 transactions from 1990 to 2022 from 34 sources through 48 different channels (21 multilateral channels and 27 bilateral channels) to 172 different recipient countries. It tracks them with 84 variables, which contain for example the geographic region, the health focus area and further information. For 2022 the aid allocation data is not specified (Institute for Health Metrics and Evaluation (IHME), 2024).
This paper deals with the changes of health funding allocation over time, but from a network point of view. It analyzes how the influence of certain sources and NGO´s changes over time and tries to find out whether there are certain recipient countries that deal with the same health issues through community detection and highlights the role of the United States capturing the changes in its policies since 1990 using multiplex network construction and analysis.

Analysis & Results

To analyze the database the python package NetworkX and the corresponding functions were used. A jupyter notebook on Kaggle was used to analyze the database.

Centrality measures

Centrality measures quantify the importance or influence of a node in a network. This importance depends on a node's position, not only on its degree. Features like pathways, connectivity and influence are also quite relevant. Degree Centrality describes the number of connections a node has, or better the proportion of nodes a given node is connected to. It can be measured in two different ways, depending on the directedness of a graph and the nodes of interest. The in-degree centrality measures how many incoming connections a node has, while the out-degree centrality concentrates on the outgoing connections a node has. In this case, the distinction between those two is only interesting regarding the channels, because those are the only ones which have in and outgoing connections.

Betweenness Centrality measures how often a node acts as a connection along the shortest path between two others. This means, that a node with high betweenness centrality lies between other nodes and controls the flow of the developments aid. Therefore, it measures a node's importance based on how often it lies on the shortest paths between other nodes. First all shortest paths are calculated, then the number of paths that pass through each node are counted and normalized based on the size of the network. In this network it is especially important for the channels, because that means that a channel with a high betweenness centrality is an influential actor in the flow of development assistance from source to recipient (ignoring bilateral fundings as channels).

Eigenvector Centrality measures the nodes influence based on connections to other influential neighbors. A high eigenvector centrality means a node is well connected to other important nodes. In this analysis, even though calculated, Eigenvector Centrality does not play such an important role, because it is only relevant for the channels. But, as shown in the analysis, WHO has a higher eigenvector centrality than UNICEF in 1990, which suggests not only a high number of connections, but also that it is deeply embedded as a most central part of the system. The WHO holds that position throughout the years (comparing 1990, 2000, 2010 and 2020), emphasizing its standing in global health.

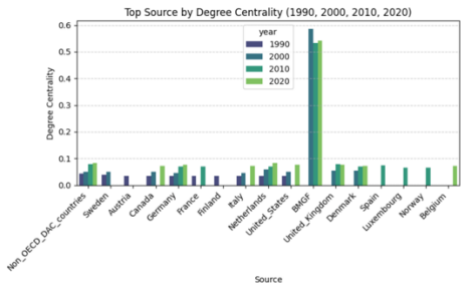


Figure 1: Top 10 Degree Centrality of Sources

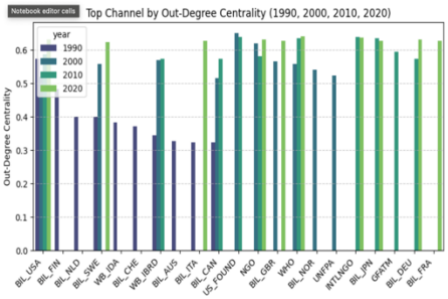
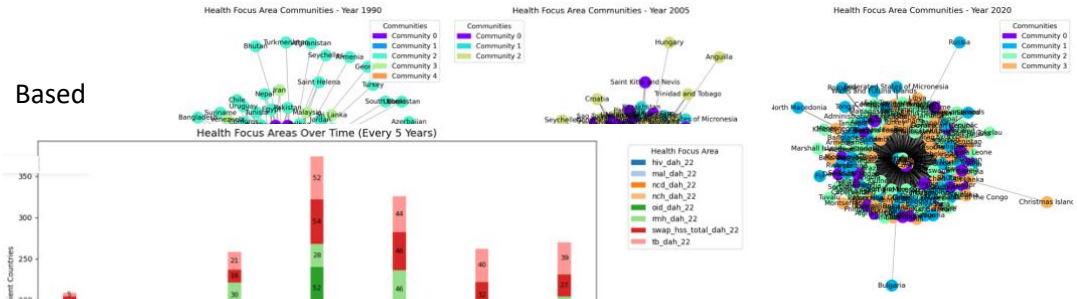


Figure 2: Top 10 Out-Degree Centrality of Channels 1990, 2000, 2010 & 2020

Bilateral aid (Sweden (0.039), Austria, Canada & Germany (all 0.034)) seems to be consistently ranked among the top especially from 2000 onward. This does not necessarily mean, that there is more bilateral aid, it just means that through bilateral aid more unique recipient countries are reached. This confirmed by the fact that international NGOs (INTLGNO) and multilateral bodes like GFATM (Global Fund to fight AIDS, Tuberculosis, and Malaria) or UNFPA (United Nations Population Fund) became increasingly central throughout time. A general shift from government-only channels starting in 1990 to a more diverse mix of multilateral and non-state actors like the WHO and BMGF is also noticeable. Over the years, the centrality value rises, the sources or channels are likely funding or engaging with more countries expanding their role in the global health aid allocation ecosystem.

Community Detection

To uncover structural patterns and evolving relationships in global health aid, the Louvain community detection algorithm was applied to a series of yearly bipartite graphs. A bipartite graph is a type of network in which nodes are divided into two disjoint sets, and edges only connect nodes from different sets—not within the same set. In this case, the two sets are recipient countries and health focus areas. This structure captures the reality of health aid allocation, where countries are connected to the categories, they receive funding for. This graph structure can also be expressed as a bipartite adjacency matrix, with rows representing countries and columns representing health focus areas, and matrix entries indicating the presence of funding. In this context, applying Louvain to the bipartite graphs enabled the identification of country groupings based on shared health aid priorities. Tracking these communities over time provided insight into how global health needs and donor priorities shifted across decades. To illustrate, the figure 3 depicts the communities of health focus areas found in 1990, 2005 and 2020. In 1990 the Louvain algorithm found 5 communities, in 2005 3 and in 2020 it detected 4 communities. In 1990, the orange Community 4 contains the health focus area tb_dah_22, which is tuberculosis, and the violet Community 0 contains the HIV health focus area.

Based 

, 2005 & 2020

Figure 4: Health Focus Areas Over Time (every 5 years)

on the community detection the analysis of the changes of number of recipient countries within a health focus area over time became possible. Lesotho for example got funding in 1990 for newborn and child health, while in 2020 the focus had shifted towards HIV and tuberculosis.

Even though figure 4 can provide a clear insight on how many recipient countries struggle with the same health issues, it might not reflect the overall global health issues. It captures the change from 2000 to 2005 for more recipient for the health system strengthening focus area (swap_hss_total_dah_22). But the number of recipients in oid_dah_22, the health focus area for infectious diseases, does not increase drastically in 2020, which could have been expected due to the Covid-19 pandemic.

Path length detection (Bilateral vs Multilateral Aid)

To detect if multilateral or bilateral aid allocation was more present and has changed over the years, the path length of the network from source to channel was calculated. This method allows to identify how efficient aid is distributed, even though in this case this method can only be used to identify bilateral and multilateral aid allocation, based on the knowledge that the channel for bilateral funding all start with 'BIL'.

It reveals that the number of multilateral paths increases steeply until 2008 and afterwards declines slightly till it increases again towards 2020.

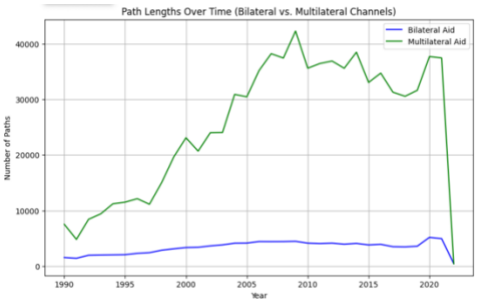


Figure 5: Bilateral vs. Multilateral Number of Channels Over Time

Multiplex network

A multiplex network was used to capture the complexity of global health aid by representing multiple types of relationships within a single network structure. In this analysis, each health focus area (e.g., HIV, tuberculosis, maternal health) was treated as a separate layer in the network, while the nodes—sources, channels, and recipient countries—remained consistent across layers. Separate multiplex networks were constructed for Germany, the United States, and the Bill & Melinda Gates Foundation (BMGF). For each donor, directed graphs were created for all eight health focus areas, where edges represented financial flows from the donor to an intermediary channel and from the channel to the recipient country. Within each layer, in-degree centrality was calculated to identify the most central nodes—those receiving the highest number of incoming connections, suggesting greater struggle in that specific area. The Bill and Melinda Gates Foundation exhibits fewer nodes and edges compared to the United States and Germany, suggesting that the BMGF adopts a more concentrated funding approach, but also could just depict the fact that the BMGF did not start giving until around 2000, giving the US and Germany a "head start" of 10 years, since this is aggregated data over the years. For example, in the hiv_dah_22 layer, the BMGF has 685 edges compared to 715 edges for the United States. This difference could also indicate that the BMGF´s funding is more targeted toward specific

countries and regions, such as Burkina Faso, Democratic Republic of Congo, and Ghana, rather than covering a broader network of countries. The BMGF´s funding is heavily concentrated in Sub-Saharan Africa, particularly in West Africa. Countries such as Burkina Faso and Cote d'Ivoire consistently appear as central nodes in various health domains. This focus aligns with the BMGF´s commitment and the behavior of philanthropic donors to addressing health disparities in regions with the greatest need (least developed countries (LDC)). While countries, such as US and Germany tend to focus more on low to middle income countries (LMDC) in their aid allocation, which the results of the analysis support (Collier, 1997; Chong & Gradstein, 2009). The US focuses more on East and Southern Africa, with notable funding in countries like Tanzania, Kenya, and Uganda, as well as South America (which are LMDC). While Germany, has a regional emphasis on West Africa, with funding directed to countries like Ghana (LMDC) and Burkina Faso (LDC).

In addition, a temporal multiplex network was constructed for the United States, using years as layers instead of health areas. This allowed for the exploration of how the US's aid distribution structure evolved over time, highlighting changes in funding strategies, channel preferences, and recipient engagements. It shows significant growth in both the number of nodes and edges, with nodes increasing from 118 in 1990 to 158 in 2020, and edges growing from 186 to 954. This indicates a clear expansion of global health aid and interactions over the years. A central feature of this network is BIL_USA (bilateral US aid), which consistently ranks as the most central node across all years, with high centrality scores above 0.8. This reflects the constant dominant role of bilateral aid in the health sector. Other prominent central nodes include WHO, GFATM, and various NGOs, highlighting the increasing importance of multilateral collaboration in the network, with increasing degree centrality values through time (WHO 1990: 0.4786 2010: 0.7037).

In 1990, major recipients included Democratic Republic of the Congo and Haiti, while by 2020, countries such as Bangladesh and Myanmar emerged as key recipients, such as “Global” recipients. In general, the number of incoming funding has increased a lot, from only 3 incoming connections for Haiti in 1990, to 11 incoming connections for Bangladesh in 2020. The growing involvement of organizations like GFATM and NGOs demonstrates a shift toward multilateral partnerships and a more diverse set of recipient countries across different continents until 2020.

Discussion & Conclusion

This analysis showed that network analysis can extract valuable information out of the DAH database, however, it did not investigate the amount of aid given by the sources. It is important to do that to be able to fully understand the picture, because it is not sufficient to only track whether there is funding present or not, not how much. Because the aid could be very small, whereas others are large donations and they both count the same in this approach. This could have been approached by weighing the edged/connections. But it might be more efficient and easier to not use network analysis. An interesting discovery was that the network analysis confirmed the broad aspects of what was/is going on in the official development aid globally throughout time. It follows the phases of aid allocation in general, and even some slight signs of covid are notable in the end, which is best observed in Figure 5. After the cold war ended, ODA kind of lost its purpose of “securing allies” until the “war on terror” was declared after 9/11, which forced an increase in investment in ODA to stabilize countries (also visible in the increase of recipients in the health system strengthening focus area in 2005 in Figure 5). This went hand in hand with the “scaling up aid” approach of the Millenium Development Goals. Since then, it is possible to observe the increased importance of public private partnerships (such as GAVI) and private philanthropy, like the Bill and Melinda Gates Foundation (*World Development Indicators*). The economic crisis in 2008 is also visible in the decline in of the number of multilateral aid paths in figure 5. The impact of the Covid-19 pandemic is not so clearly visible in this data, due to its lack of allocation after 2021, as well as the missing analysis of the amounts of aid spend (Collier, 1997; Chong & Gradstein, 2009; Frot, 2009).

To conclude, this approach still has a lot of flaws and limitations which could have been approached in a more elegant way, but I was truly surprised about what was possible after almost thinking that a network approach would not work for this data, due to its limited connectivity.

References & Appendix

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All figures and data frames are in the provided material and the code.