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Visualizing Offshore Foreign Direct Investments: The Atlas of Offshore

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Abstract | Foreign Direct Investment (FDI), or controlling investments that cross national borders, is in many respects the backbone of globalization. However, a considerable part of it is composed of "paper" shell companies used for tax avoidance and other purposes. While it is possible to reconstruct chains of FDI positions, it is difficult to raise public awareness of the full scale and shape of the phenomenon, in terms of not only the countries or amounts of money involved, but also the high levels of uncertainty surrounding estimates of these figures. In this paper we introduce the Atlas of Offshore, a visual exploratory tool meant to enable domain experts and broader publics to explore offshore finance, with a focus on clearly showing the complex webs of relationships between countries involved. Starting from a variation of the "Sankey Diagram", we propose a solution aimed at representing the topology of the network, the estimated size of investments, and the uncertainty surrounding these estimates. A prototype of the tool has been developed, testing the visual model with data describing the network of offshore investments for nine countries, enabling domain experts and others to obtain a new perspective on this issue.

KEYWORDS | BUSINESS AND FINANCE VISUALISATION, FLOW VISUALISATION, AESTHETICS IN VISUALISATION, UNCERTAINTY VISUALISATION, GRAPH/NETWORK DATA

1. Introduction

In this paper we describe the preliminary results obtained in the design of a visualization tool facilitating visual exploration of offshore financial relationships. This was undertaken as an interdisciplinary collaboration between an economic geographer, two information design researchers and two researchers with a background in media studies and science and technology studies. The working prototype, described in this paper, can be found at this link: https://offshoreatlas.publicdatalab.org/explorer.

The starting point is the economic geographer's work constructing a novel database of the estimated offshore investment relationships between specific countries. The construction of this very large network database raised an issue; namely, how to represent "complexity without spaghetti", or, in other words, render the structure of relationships intelligible, rather than simply overwhelming. At issue here is not simply the analysis of the database, but also the question of using creative visualization tools to render complex economic phenomena legible to a relatively broad societal audience.

The visualization techniques deployed here represent an attempt to strike a balance between across two key dimensions of tensions. Firstly, as noted above, there is the desire to show both the detailed structure of international economic relationships, and the key "big picture" elements of these relationships. Secondly, and just importantly, however, there is the desire to both show our best-available current understanding of these relationships, and the willingness to avoid creating a false sense of certainty potentially shutting down public conversation (Latour & Weibel, 2005)surrounding what remains, even with the application of novel estimation procedures, a fundamentally opaque and poorly understood element of the world economy. What is particularly crucial to convey here— and what is currently not well-recognized by even many expert—is that the massive scale of the offshore data "black hole" at the heart of the world economy means that we do not really understand even many of the most basic contours of the shape of the latter (Damgaard, et al., 2019). Indeed, as Maurer (2008, p.160) puts it, "Far from a marginal or exotic backwater of the global economy, offshore in many ways is the global economy."

Not surprisingly, these are not new dilemmas, and we can thus specifically situate the atlas project against broader debates around the knowability, unknowability and governability of transnational economic activity (Slobodian, 2018); the infrastructural configurations of relations between markets, states and citizens (Roberts, 2010); and the need for data practices that fully respond to and reflect uncertainty (Anderson, 2018).

1.1 Foreign Direct Investments

Foreign Direct Investment (FDI) consists of controlling investments by companies and individuals that cross international borders. FDI is often considered to be the backbone of the global economy, as it is created whenever a company makes cross-border investment in a factory or other facility or acquires or merges with a company in another country.

However, FDI also consists largely of “paper” shell companies used for tax avoidance and other purposes (Haberly & Wójcik, 2015). In fact, data from the International Monetary Fund (IMF) show that this offshore component of FDI —which is generated as a by-product of tax avoidance and other offshore games— may actually be larger, in total, than the amount of FDI that is not in some way linked to or distorted by offshore structures. As of 2016, roughly two thirds of all worldwide FDI recorded by the IMF —likely accounting for at least 40% of the underlying capital invested (Damgaard, et al., 2019)— was either in or from "offshore" jurisdictions whose investments are believed to consist largely or mostly of foreign-controlled shell company structures.

1.2 Dataset

Growing awareness of these problems among researchers and statistical agencies has led to a concerted effort to shed light on the contents of the offshore black box at the heart of the global FDI network. The OECD has begun to coordinate efforts by major developed economies to compile information on the ultimate, rather than just the immediate origin of FDI entering them (Damgaard & Elkjaer, 2017).

Ongoing Country-by-Country-Reporting (CBCR)[1] and beneficial ownership reporting reforms at the national and international level hold the promise of further improvements in official data (Wójcik, 2015). At the micro (company) level, databases such as Orbis[2] have opened the door to efforts to reconstruct our picture of the global shell company network from the “ground up” (Garcia-Bernardo, et al., 2017) while statistical methodologies have been applied to macro-level data to infer the structure of parts of the network that cannot be directly observed (Casella, 2019; Damgaard & Elkjaer, 2017; Haberly & Wójcik, 2015).

The dataset is the result of a methodology (Haberly, forthcoming) based on multiple micro (Orbis) and macro-level (OECD, IMF, and US BEA) datasets. It allows us to construct a multidimensional matrix of offshore FDI positions, cross-disaggregated across ultimate home country and two different layers of conduit jurisdictions,[3] in nine major economies. Each country can, therefore, have four possible roles in the network, sometimes simultaneously:

1. **Source:** “true” ultimate investing country;
2. **Secondary conduit:** “ostensible” ultimate investing country (i.e. reflecting offshore incorporations/inversions at the parent company level);
3. **Primary conduit:** immediate (conduit) investing country;
4. **Target:** destination country.

[1] to foster tax transparency OECD required all multinational enterprises to provide the global allocation of their income, taxes and other indicators of the location of economic activity.

[2] Orbis is Bureau van Dijk's flagship company database.

[3] FDI Positions are the cumulative value of investments at a given point in time.

The dataset simultaneously highlights where international investors/multinational firms claim to be based and where they are “really” based, as well as the jurisdictional pathways that they use to invest in particular host economies. The dataset is structured as independent networks based on nine destination countries that encompass more than half of the world economy: United States, Russia, United Kingdom, China, Italy, Brazil, India, France and Germany.

The constructed dataset contains a high level of uncertainty. As argued (Damgaard, et al., 2019; Damgaard & Elkjaer, 2017; Linsi & Mügge, 2019), official economic statistics and FDI statistics in particular, are far less reliable, and have much larger gaps than is often assumed. In this case, the lack of official data on offshore investment chains has made it necessary to estimate the value of these chains through a Monte Carlo simulation approach, which generates a very large number of possible scenarios of what the structure of these chains could be based on a mixture of known (fixed) and estimated (variable) data points fed into the simulation. The dataset thus does not consist of individual estimates of the value of investment positions, but rather a “cloud” of investment probability distributions, which may be wide or narrow for any given investment chain.

2. Related work

Although there is a long tradition of exploring public finances with information graphics (Gray, et al., 2016), it appears that public spending has featured more prominently in such projects than taxation or revenue (Gray, 2015). Offshore finance has been covered by journalistic media reporting specific cases of scandals that represent a portion of the phenomenon. Recurring visualization strategies include scrollytelling with data, for example “Swedes in Paradise Papers” (Hjalmarsson, et al., 2017), and explorable network graphs, mostly ego-networks (Freeman, 1982) and detecting key players (Bounegru, et al., 2017), for example in “The Power players” (International Consortium of Investigative Journalists, 2016). The project “Swedes in Paradise Papers” describes Swedish people involved, representing them by dots that are clustered according to demographic characteristics. In “The Power players” case, the stories focus on evidencing the relationship between individuals and entities, filtering leaders and politicians according to countries and world regions. A non-journalistic case is the project “How complex are corporate structures?” developed by the NGO OpenCorporates (OpenCorporates, 2013) that relies on geographical representation to show the connections and location of offshore companies related to the seven main US banks. The result is a deformed map that visualizes only the offshore companies through points, showing the financial geopolitics of world offshore "hubs". Much of the coverage associated with such leaked databases has focused on the role of specific actors (e.g. politicians, celebrities), countries, or the story of the leaks themselves, rather than what they can tell us about the structure and transnational dynamics of offshore finance. Meanwhile, in an academic setting, the CORPNET research group has produced more comprehensive (albeit static) visualizations of the structure of the global financial

networks (Garcia-Bernardo, et al., 2017) using conventional network visualization tools such as Gephi's ForceAtlas2.

3. Design approach

The dataset consists of investment relationships that pass between countries via layers of other jurisdictions. Each relationship in the dataset can be seen as an investment chain comprising all successive steps from the country where an investment originates to the destination one. Each chain can represent a direct investment from the source to the destination country, or indirect investments involving one or two "conduit" countries between the origin and the destination.

By aggregating these chains, the underlying topological structure is composed of countries (which are the nodes) linked by investments.

Two countries can therefore be linked by several kinds of investments. In other words, countries may assume different roles according to the links they have with other countries in the sequence of how the investment goes through including ultimate origin, primary (parent company-level) conduit (e.g. for offshore corporate "inversions"), secondary (subsidiary-level) conduit and destination. The main problem posed by this particular data structure is what visual model should be used to represent such a multilayered, as opposed to simply bilateral, network structure.

3.2 Design requirements

The data structure brings three main problems in the visual model design. Each country can have simultaneously multiple roles: for example, being source for some investments, and conduit for others, or either target (Figure 1). Furthermore, investments chains can be aggregated or disaggregated between each pair of nodes. Finally, these structures can easily involve loops among countries, which in practice tend to dominate the figures due to the pervasiveness of offshore "round-tripping" (Haberly & Wójcik, 2015).

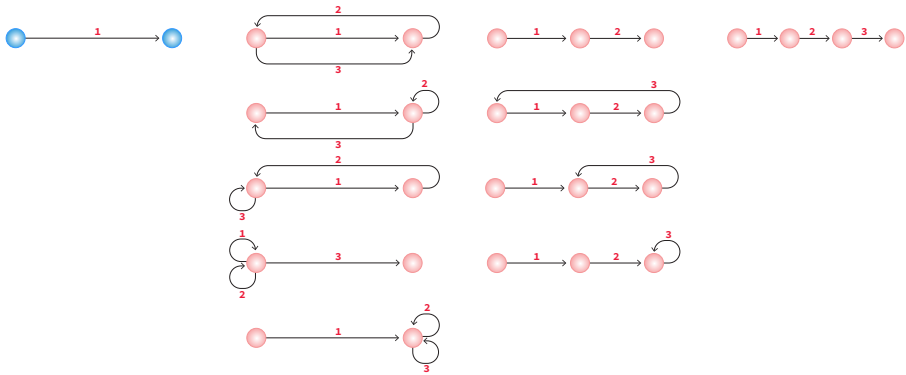

Figure 1. Diagram showing how investment chains could aggregate or disaggregate among a set of countries. Blue color chain is a direct investment while other combinations are indirect.

The described prototype has been created with the goal of representing in an efficient way to allow the database creators to disseminate results.

After discussing with the database creators, we identified the following design requirements:

- **R1.** Provide an overview of all the investment chains related to a specific country;
- **R2.** Show all the kind of chain couples (source to the primary conduit, primary to the secondary conduit, secondary conduit to the target, primary conduit to the target, and source to the target);
- **R3.** Highlights chains passing through conduits, rather than going directly from source to destination;
- **R4.** Enable the aggregation of chains passing through a group of countries;
- **R5.** Enable filtering of chains passing through a group of countries;
- **R6.** Show the value of uncertainty;
- **R7.** Show the amount of investments related to each flow;
- **R8.** Show the total amount of investments positions for each country;
- **R9.** Show the proportion of investments per country role (source, primary conduit, secondary conduit, destination);
- **R10.** Show flows directions.

3.2 Visual model design

Being a graph structure, the first tests entailed adopting a network diagram. This visual model provides an overview of all the investments targeting a specific country (R1) and would easily allow aggregation and filtering operations (R4, R5). This was indeed the first solution adopted by the database creators to represent such data.

However, the dataset is not simply composed of bilateral links between nodes, but rather by chains of links through layers of nodes. This means that the same pair of nodes can be linked by several flows following different directions. Furthermore, a conventional network diagram is not efficient in representing the different role that a country could have. It creates visual ambiguity about the nodes' sizes (i.e. the role in investment that this refers to) and make it difficult to automate node positioning due to the complexity of link chains.

In the current case, nodes are more likely conduits through which the investment chains pass. The same investment chain could pass twice through the same node in some situations, and the same node could play different roles in different chains.

Among network representations, we focused on the Sankey diagram for its ability to represent transfers or flows within a system (Schmidt, 2008). The model is usually composed of rectangles to represent the different nodes of the system and ribbons to represent the flows. The model keeps most of the advantages of network diagram and is more efficient in representing relative proportional breakdowns among flows and nodes (R7, R8). By using vertical bars for nodes, it allows to clearly show the total size of investment positions in a country as the height of the bar is proportional to the thickness of lines entering it.

Representing the nodes as bars helps visually differentiate between the roles played by each node (R9), through use of groups of stacked bars. Conceptually, each node in the diagram is in fact a group of nodes (one for each possible role in chains of investment) and therefore is possible to show how each pair of nodes is connected. For example, the node representing Netherlands in the network of investment entering the UK (Figure 2) is actually composed of three sub-nodes): Netherlands as a source, as primary (parent company-level) conduit, and as secondary (subsidiary-level) conduit, within any given chain of investment in the UK. Each of the sub-nodes can have both inward and outward investment links to any other sub-node.

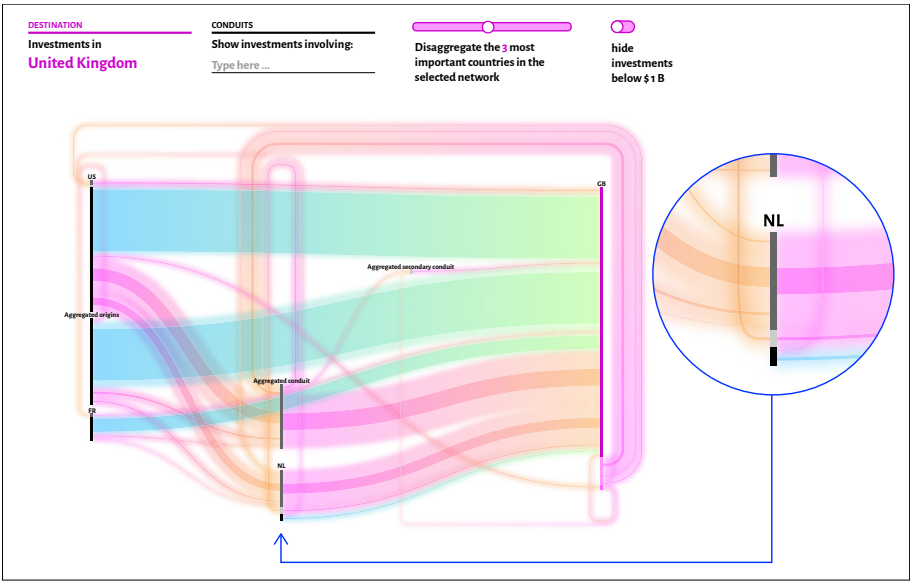

Figure 2. Example of a node with multiple roles: in the UK network, the Netherlands act as source (black bar), primary conduit (dark gray bar), secondary conduit (pale gray bar).

Through initial graphical tests, the arrangement of nodes in space (both the horizontal and vertical positioning) emerged as crucial in communicating the main role of each country. The automated layouting, as the one present in the D3.js code library adopted in the prototype (*D3/d3-sankey*, 2015/2020), was not efficient due to the large number of links among nodes: in the test, users were confused about the meaning of nodes' positions. To define a common positioning model, and to consistently highlight the role of each country in the network (R9), it was adopted a disposition based on the total amount of investment per type.

The value of all the investments passing through a node are aggregated by node role, and the most important role for each country (in terms of amount of investment) is used to define the position of nodes from left (predominantly sources) to the right (predominantly targets). Vertical node positioning doesn't encode any information and is simply optimized to minimize figure overlaps.

Finally, we designed the visual attributes of links. Two main pieces of information are shown here: the direction of investments (R3) and their typology (i.e. if direct from source to target, or conduit-mediated). Regarding investment direction, several solutions were tested, and gradient-based animations were used to graphically show which way money is moving. The types of investments are differentiated by color. Direct investments (i.e. not mediated through a conduit) were represented with green-blue gradient animations. Meanwhile,

investments indirectly mediated through conduits (including offshore investment positions) were represented with orange-fuchsia gradient animations.

3.3 Portraying uncertainty

The next task was to portray the uncertainty surrounding the value of investments (R6), which is estimated here in the absence of officially published data. For each investment, we have a "cloud" of investment size probabilities (in billions of dollars), that can be summarized in terms of statistical confidence bands. While there are a number of studies on the visualization of uncertainty (Bonneau, et al., 2014) few of them are focused on network diagrams, and in particular on uncertainty related to edges. Schwank tested several methods to portray uncertainty surrounding edge existence (Schwank, et al., 2016). The key result is that blur is a good solution to convey uncertainty. Furthermore, blur proved to be efficient in quickly enabling users to identify the most certain elements (Kosara, et al., 2002) even if not very efficient in communicating fine gradations in uncertainty level.

In the project, uncertainty is not related to the existence of a link, but rather to its weight. As out estimates take the form of statistical confidence bands, we adopted a mixed approach: the lower-bound (more certain) is drawn as an inner sharp line for each investment, while the upper-bound (less certain) estimate is drawn as a blurred outer line. The larger the blur, the larger the uncertainty (Figure 3 and Figure 4).

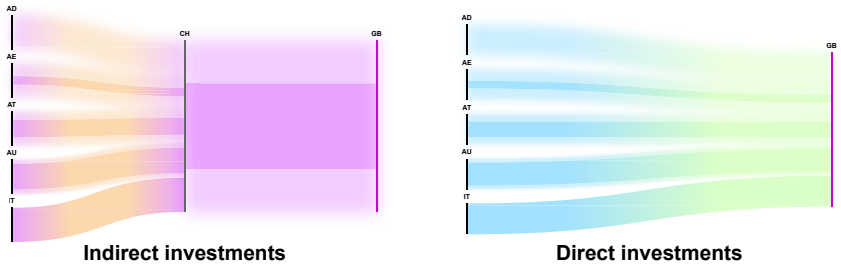

Figure 3. Example of how uncertainty level is encoded for indirect conduit (pink-organge) and direct (blue-green) investments, via blur.

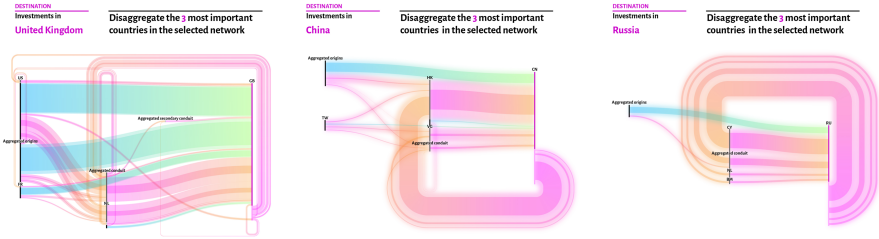

Figure 4. Visualizations of the networks of United Kingdom, China and Russia as destination countries for foreign investments, aggregated to show the 3 most important investment source and conduit countries investing in each. Note the much higher levels of blur, in general, for indirect investments passing through conduits —most of which are offshore jurisdictions— reflecting the much greater uncertainty surrounding these estimates.

3.3. Interaction design

The visual model proved to be useful in expert user tests examining a subset of data, but still too complex when attempting to show the whole database; a problem amplified by the fact that each pair of countries can be connected by several links depending on role. Furthermore, investment values fall along an enormous range, rendering the smallest ones almost invisible in the complete network. To solve these two issues, we adopted two solutions: filtering (R5) and aggregation/disaggregation (R4). The first reduces the portion of dataset visualized; the second changes its representation according to aggregation level. Both can be applied in combination.

The user can filter the investment chains displayed by selecting one (or more) countries. For example, selecting “Netherlands” will show only investment chains passing through this particular country in a role as source, conduit or target.

To reduce the visual complexity, the user can aggregate all investment chains (via a node labelled “aggregated” for each role) not involving the selected number of most important nodes in the network. At the maximum level of aggregation, only four nodes are visible: one for the target country and one for each “aggregated” jurisdiction role in the network. With a slider it is possible to progressively increase the number of individual countries that are shown in the diagram and related investments.

The interface was then enriched adding the ability to select individual nodes and links (countries and investments). Clicking on a country opens a panel showing that country’s location on the globe, as well as other key information regarding its investment pattern. Clicking on an investment it opens a panel that disaggregates all of the individual investment chains comprising it.

4. Case study / annotated lectures on the diagram

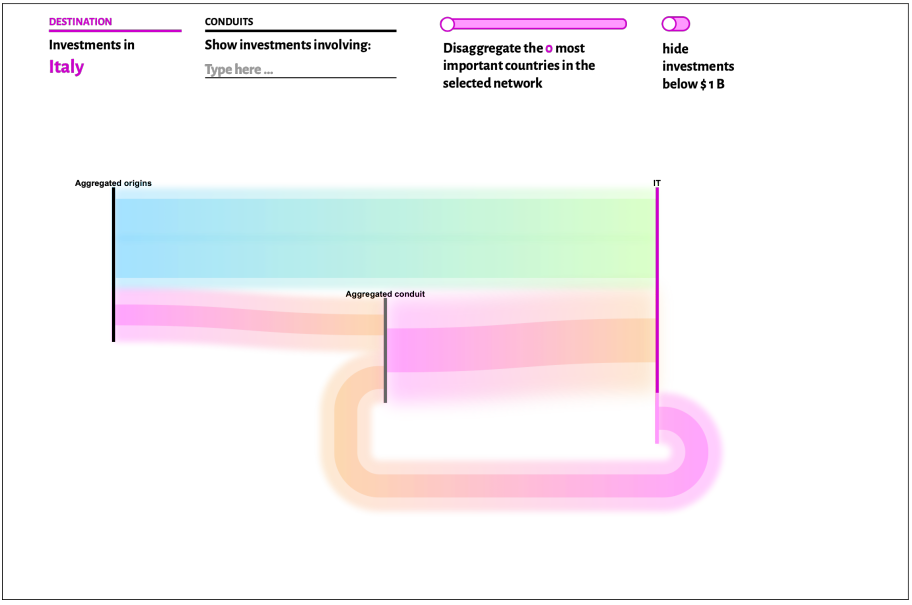

Figure 5. Network of investments targeting Italy at the maximum level of aggregation.

As an example, we can consider the network of investment targeting Italy as a destination country. At the maximum level of aggregation (Figure 5) it is possible to see that there is a single broad green-blue inflow of investment that enters Italy directly without passing through a conduit. There is also an orange-pink link entering Italy via an aggregate conduit jurisdiction — with half composed by investment ultimately originating from other countries, and half of "round-tripping" from Italy itself. From the blurriness it is also possible to see that (blue-green) direct investment that does not pass through conduits is characterized by much lower levels of estimation uncertainty than investment that enters via conduits.

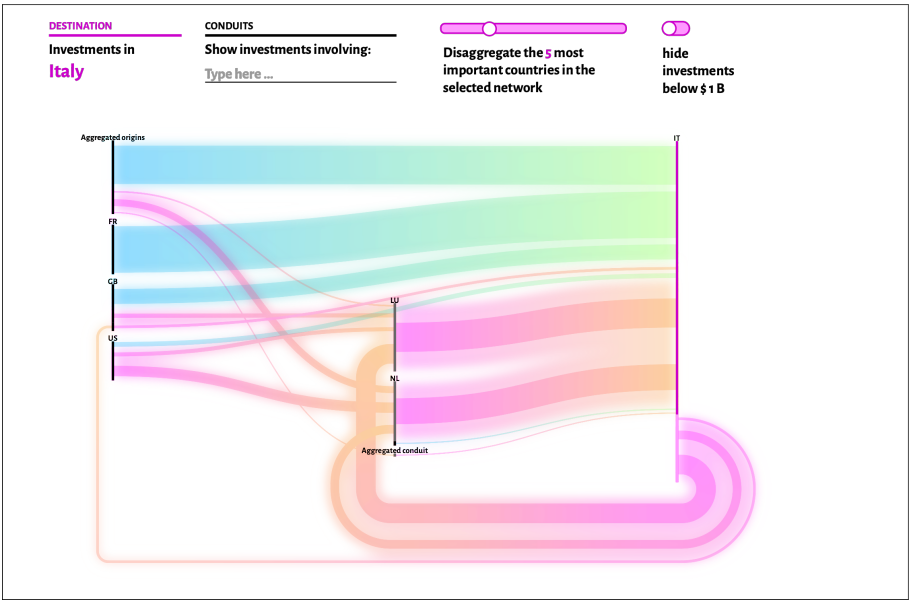

Figure 6. Network of investments targeting Italy, disaggregating the 5 most relevant countries.

By disaggregating the five most important countries (Figure 6) it is possible to see the different roles played by key source and conduit countries in the network. On the right is the target country (Italy). On the left are countries that are primary ultimate sources of investment: from France (FR) there are mainly direct ("onshore") investments, while United States (US) investment mostly enters Italy indirectly via conduit structures in the Netherlands (NL) and Luxembourg (LU). The United Kingdom (UK) plays a more complex role: it is mainly source of direct ("onshore") investment into Italy, but also both invests in Italy indirectly via conduit structures, and acts as a conduit jurisdiction itself for other countries' investments in Italy. In the middle of the diagram are the principal "conduit" countries: the Netherlands and Luxembourg. These are leading tax haven jurisdictions that both channel foreign investment into Italy, and are widely used by Italian firms and families as nodes in "round-trip" structures (i.e. where their domestic holdings in Italy are owned via offshore structures). While from the Netherlands there is also a small share of (blue-green) investment from "legitimately" Dutch companies, Luxembourg acts almost entirely as an offshore conduit, particularly for Italian round-tripping.

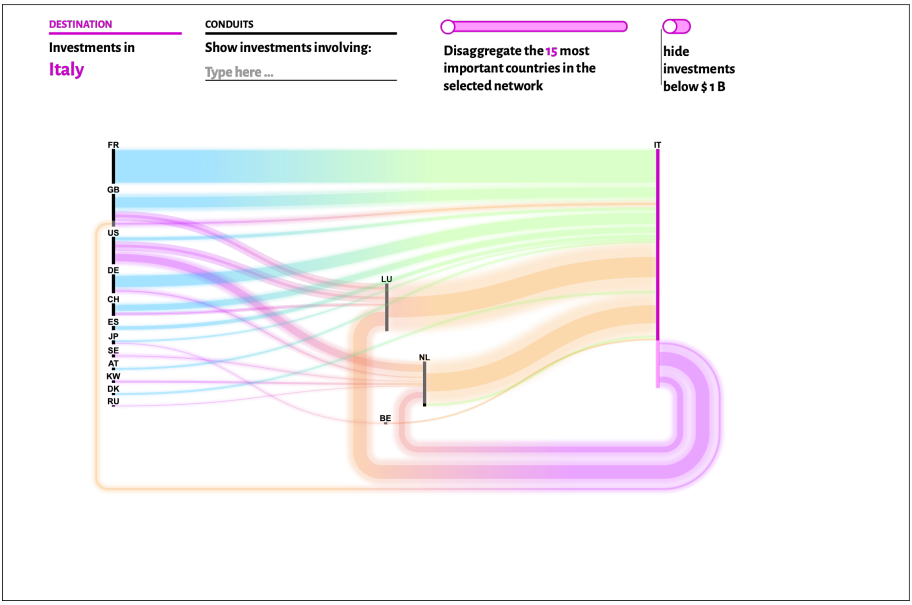

Figure 7. Network of investments targeting Italy, completely disaggregated.

Finally, by completely disaggregating the network (Figure 7) is possible to see the role of all countries providing or intermediating at least $1 billion of investment in/to Italy.

5. Conclusion / Preliminary test

In this paper we have examined the design process and decisions involved in creating the data visualization tool for an "atlas of offshore finance". We presented two design challenges surrounding the visualization of a complex multidimensional network dataset with multiple tiers of links; and the visualization of uncertainty in data based on probability estimates. After defining design requirements, a visual model and interactive strategies have been designed. The proposed solution is an interactive application based on a variant of the Sankey diagram. The application provides an overview of investments chains for a given target country; represent all the possible connections between it and layers of source and conduit countries; deals with problems of scalar differences and data overload by using filters; allowing for different flow configurations to be selectively aggregated or disaggregated; and conveying data uncertainty via the visual variable of blur.

In conclusion we offer some final reflections on what we have done and how this might point towards further work. It is important to mention that this paper focuses on the first phase of this project, namely the production of an application primarily targeted at domain

experts and initial dissemination of the results. It is also the first attempt to define a consistent visual language for the communication of such data.

While we have consulted researchers, civil society groups and other issue experts during the design process, the next phase of the project will be to enter into a public "beta testing" moment to examine broader responses to the project and to understand how this might inform further design activities.

As other researchers suggest, transparency initiatives do not only cater to pre-existing publics, they can also play a role in gathering and assembling publics (Barry, 2013; Di Salvo, 2009; Ruppert, 2015). We might thus further explore the capacities of these visualizations to gather publics and to organize material participation (Marres, 2012) in specific ways around the issue of offshore - including, e.g., relations between citizens, civil society groups, journalists, public institutions, researchers and financial industries. In future work we are particularly interested in how data visualizations may play a role beyond communicating information, including, for example, their capacities to facilitate affective engagements (Kennedy & Hill, 2018), witnessing (Gray, 2019), journalistic reporting and advocacy, the ability to create alternative narratives challenging dominant power structures (Briones Rojas, 2019).

What is particularly interesting about the case of offshore is precisely that public intelligibility is part of the issue: the numbers and estimates have been hotly contested, civil society responses have been questioned by industry, and the esoteric nature of the subject matter makes key concepts resistant to easy communication. The challenge of facilitating broader public engagement around this issue is therefore how to design visualizations which avoid misplaced precision (implying an unfounded level of certainty), whilst at the same time avoiding a kind of "data sublime" (Davies, 2015; Gray, et al., 2020) of visualizations which inadvertently reinforce the notion that offshore finance is unfathomable and publicly unintelligible. Thus, we seek to open up public debate and engagement, rather than closing it down through the affirmation of either certainty or unknowability.

Finally, the collaborative design process between researchers with different backgrounds allowed the discussion, reflection and representation of the FDI phenomenon to be conducted from multiple angles and levels. The nature of the phenomenon is not only financial, opening up issues that involve the politics of data in the construction of societies.

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