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Challenges in Accurately Tracking Copper Trade Flows

By Zach Krause

Copper is among the most heavily traded commodities world-wide. The trade volume of copper in combination with the environmental impact of the mining industry has drawn increased attention to the processing and trade of copper and other primary metals. Moreover, copper is a metal that is essential to the energy transition as a component of renewable technologies. To prevent further climate related change, it is important to understand the movement of copper around the globe. This body of research and the existing literature demonstrate that copper trade flows range in complexity from regional partnerships to global regimes. The broad range of complexity contributes to many different narratives that describe the flow of copper ore and concentrate, which further complicates explaining the link between trade flows and environmental impacts.

To examine the trade flows of copper ore and concentrate, a three-year-average was taken from the top-15 copper ore and concentrate exporters from 2018-2020. These averages were then examined for unique relationships.

Copper is traded in various forms, all of which have different amount of contained copper. Copper ore is the material that is direct from the mine, with the average global ore grade being 0.62% (meaning that the average copper ore is composed of 0.62% copper). At first glance, it seems improper to export copper in the form of ore and concentrate, as copper concentrate generally contains between 20-30% copper depending on its point of origin and method of concentration. Transporting concentrate that only contains between 20-30% copper, and ore which contains even less, appears inefficient relative to transporting a more refined form of copper, such as cathode.

Even across shorter trade routes, it is inefficient to transport such high quantities of waste material. During shipping, emissions intensity is linked to total weight of the product being transported, including waste material. When large quantities of ore and concentrate are transported, there is a great deal of waste as well as other valuable minerals present in the material. The process of allocating emissions to various contained metals and waste material can complicate the understanding of the emissions intensity that is unique to copper. Nonetheless, as demand for copper increases, countries may specialize in various stages of mining and refining, rather than processing copper from ore to cathode.

Another area that complicates the understanding of copper trade flows and their resulting emissions is the diversity of material that falls under the category of *copper ore and concentrate*. Much of the data analyzed and presented here is found under the HS six-digit code 260300: *copper ore and concentrate*. This category captures material that ranges from approximately 0.62% to 30% contained copper. The difficulty in comparing this data is expressed by the range of unit prices attained from the data set. The World Bank data used in this analysis provided both a trade volume and a trade value, making it possible to calculate an average unit price of the material that was being exported from each country. The unit prices of copper ore and concentrate varied drastically, ranging from about $51 million USD/kt to $10,000 USD/kt, with a median value of 1.4 million USD/kt. From this disparity in value, it is evident that the copper ore and concentrate being traded have a wide range of contained copper. Additionally, given such a large disparity in value, it is possible that there are errors in reporting. Moreover, the diversity in material that falls under the category of *copper ore and concentrate* makes it challenging to accurately attribute emissions to the material.

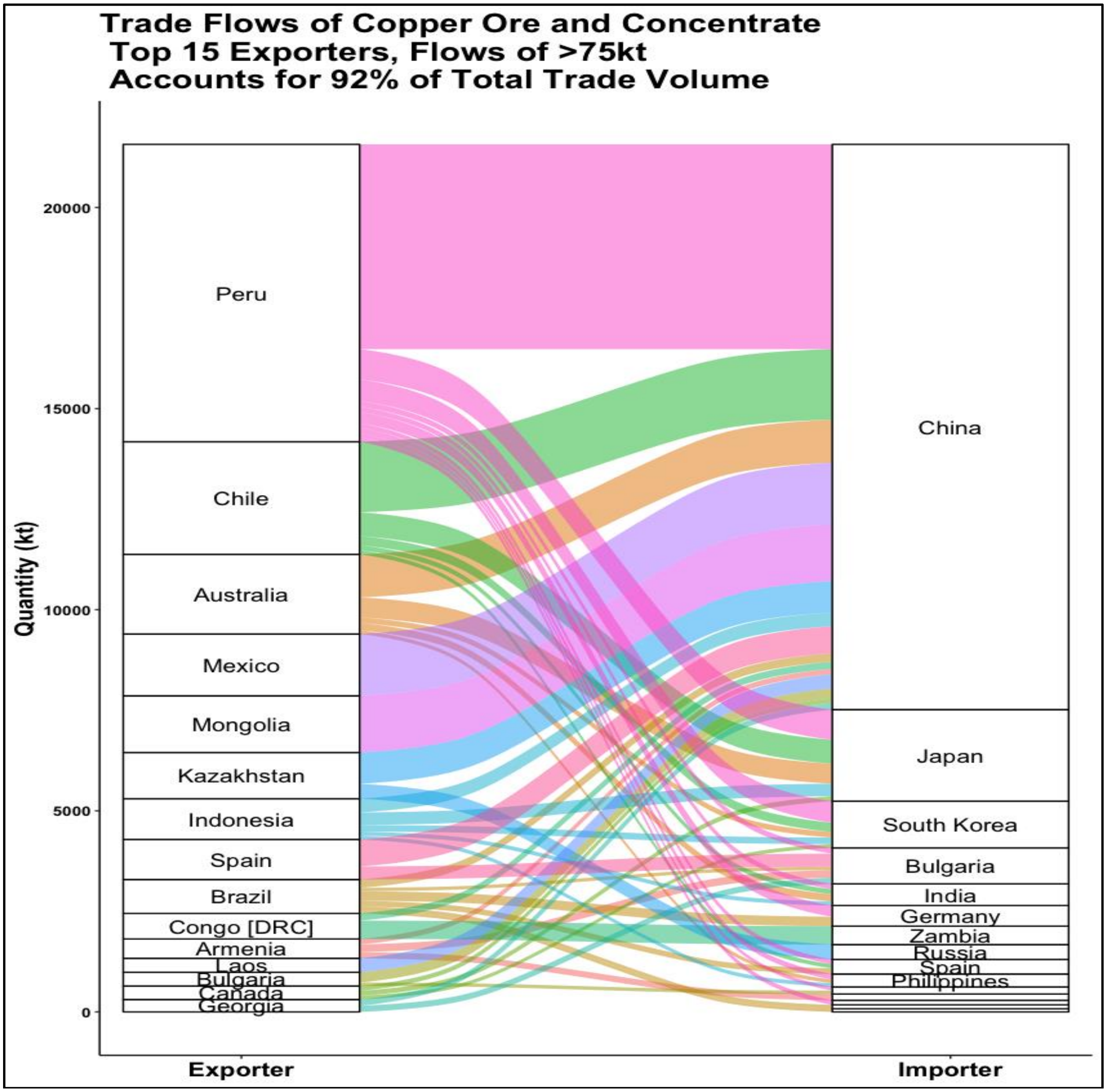

Figure 1: World Copper Trade Alluvial Diagram

To visualize the trade of copper ore and concentrate, **Error! Reference source not found.** was created. The diagram displays the top-15 exporters of copper ore and concentrate (average values from 2018-2020) on the left, and the importing countries on the right. The various colored flows display the relative size of each trade relationship. While this data is helpful to illustrate the volume of material that flows around the globe, it does not express the amount of contained copper.

Peru is the dominant exporter, while China is the dominant importer of copper ore and concentrate. While Peru is the greatest exporter by volume in this data set, Chile is the greatest exporter by value, indicating that the product being exported from Chile has a greater quantity of contained copper. When more refined forms of copper are considered, Chile is widely regarded as the World's leading producer of copper. China is by far the greatest importer of copper ore and concentrate, and imports copper ore and concentrate from all of the top-15 exporters. Given that China imports such a great quantity of copper ore and concentrate, it is necessary that the amount of contained copper is reported rather, than simply a volume under the broad category of ore and concentrate. Knowledge of the amount of contained copper within the volume of ore and concentrate would help illuminate how transport emissions could be reduced by shipping more refined material and what portion of downstream emissions remain in the process to refine the copper into cathode. China's dominance as an importer is fueled by its rapid pace of development. Securing primary metals such as copper is essential for China to continue its development, and secure its supply chain as the World looks toward the energy transition.

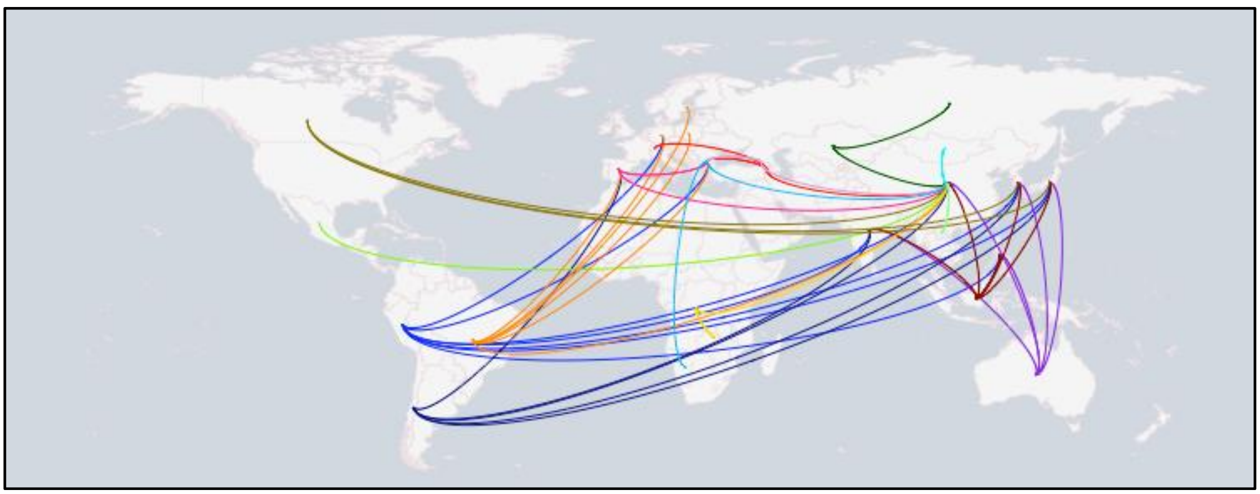

Figure 2: World Trade Map (top-15 exporters, all flows above 75 kt)

Countries such as Brazil, Chile, and Peru trade with a greater number of trade partners than many other exporters in the top-15 (dozens more when flows of less than 75 kt are considered), while other exporters trade relationships are more regionally defined. Trade relationships often change from year to year, especially in countries that have a larger quantity of trade partners. The diversity of trade relationships can be seen in Figure 2. Constantly changing trade relationships add another factor of complexity in accurately measuring contained copper in material flows and the associated emissions.

Conversely, regionally defined trade relationships serve to reduce long-term emissions within the copper industry, especially with respect to the shipping of materials that contain relatively lower quantities of contained copper. While reginal trade relationships of unrefined copper products can serve to reduce emissions, it is unlikely that all trade relationships will become regionally bound.

Major exporters such as Chile and Peru hold such a large percentage of global supply that it would be impossible for major importers such as China to satiate their demand without trading with South American producers

For example, both The Democratic Republic of Congo and Indonesia (Figure 3) have regionally defined trade relationships in the export of copper ore and concentrate that differentiate them from other leading exporters. Indonesia exports ore and concentrate quantities exceeding 75 kt to China (343 kt), Japan (312 kt), South Korea (164 kt), India (101 kt), and the Philippines (94 kt). Another unique trade dynamic is that of The Democratic Republic of Congo, whose only trade relationships exceeding 75 kt are to Zambia (458 kt) and China (177 kt).

Figure 3: DRC and Philippines Trade flows above 75 kt

The narratives that surround regional trade relationships are often easier to describe than globally diverse trade relationships. Within the DRC, many of the development projects, especially mining projects, are financed by Chinese companies. Financing mining in Africa allows Chinese companies to secure trade relationships in developing areas to fuel increasing demand. The DRC's trade with Zambia is also very logical, as Zambia also holds significant copper deposits. Both the DRC and Zambia possess the machinery and the human capital to process copper ore and concentrate, making them natural partners. Trade between the DRC and Zambia also avoids export taxes and royalties that countries outside of Africa must bear if they desire to access African resources.

The trade data presented above displays that there are select regional trade relationships that may be easier to provide a narrative for and may be simpler to create emissions profiles for. Unfortunately, it is evident that the majority of copper flows are transcontinental, which makes them hard to accurately track in terms of both contained copper and the emissions associated with transport. The compounding complexities provided by the great number of trade flows and the product diversity within the category of *copper ore and concentrate* provides a challenging research and regulatory environment. The future progress of metal reporting and research will depend on increased levels of transparency, standardization, and accuracy.

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