# Growth potential for $CO_2$ emissions transfer by the United States-China trade battle

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## 1. Introduction:

United States-China relations are at a low point. The current list of problems facing the two countries is long. There are huge discrepancies between the official Chinese and United States estimates of the bilateral trade balance. From an American perspective, the complaints include allegations of Chinese copywriter rights violations and spying; and from a Chinese perspective, among the most critical problems are issues related to the status banning Chinese telecom giant Huawei and imposing tariff barriers on exportable.

A large fraction of Chinese emissions is due to producing manufacturing goods for United States consumption. The magnitude of global $CO_2$ emissions is directly guided by international trade, which has grown faster than the growth rate of gross domestic product (GDP) (Peters *et al* 2011). Therefore, changing the trading condition between the two largest economies in the world, the United States and China, have a huge impact on $CO_2$ emissions. If environmental policies do not account for the emissions embodied in imports, global emissions are likely to rise (Kanemoto *et al* 2014).

It is unknown if tariff reform will increase the embodied $CO_2$ by a significant amount or if tariff reform will benefit the environment due to the trade battle between the United States-China. Furthermore, it is unknown how much growth of $CO_2$ emissions the tariff reallocation will induce. This issue is critical and if trade battle causes a significant increase in $CO_2$, then it will be environmentally inefficient and unacceptable. Therefore, this present trade battle and its future impacts should take a close look from the environmental point of view.

## 2. Methodology

### 2.1 Gravity model

The gravity equation is consistently used to explain different types of flows, for instance, trade, migration, commuting, and tourism (Bergstrand 1985). In our empirical analysis, we consider an adaptable regression model, based on the popular gravity model of international trade, with which we control sector specific tariff rates. In the empirical equation, we examine the impacting international trade factors on $CO_2$ emissions. The gravity model of trade considers the trade volume as a positive function of the "mass" of two economies and the negative function of the "geographic distance" between the countries. The gravity model of trade is`

$$Trade_{ij} = f\ \frac{(GDP_i \times GDP_j)}{Distance_{ij}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

The regression equation is commonly specified as

$$Trade_{ij} = a_0 +\ a_1\left(GDP_i\ \times\ GDP_j\right) +\ a_2\left(\ Distance_{ij}\right) +\ u_{ij} \dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Embodied emissions, such as international trade, are driven by the size of the economy of importing and exporting countries and impeded by the geographic distance of the countries. The joint effect of distance and importer also guide the embodied emissions. Most importantly, the tariff rate of trading goods is likely to impact the embodied emissions with imports. These considerations suggest the gravity equation for environmental embodied emissions for trading goods:

$$CO2\ embodied\ emission_{ijt} = \alpha_0 + \alpha_1\ Tariff_{ijt} + \alpha_2\ Emission\ intensity_{it} + \alpha_3\ (GDP_{it} \times GDP_{jt}) + \alpha_4\ Population + \alpha_5\ Distance_{ij} + u_{ijt} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where $u_{ijt} = \varepsilon_{ijt} + v_{ijt}$

Here, $i$ is the importer country, $j$ is the exporter and $t$ represents the year.

To determine the environmental quality, we consider embodied $CO_2$ emissions. The dependent variable $CO2\ embodied\ emissions_{it}$ is the $CO_2$ footprint of a product. It considers the emissions by the total processes associated with consumption. $GDP_{it}$ and $GDP_{jt}$ are the input of the importers and exporters GDP at time *t*, respectively. $Distance_{ij}$ is the geographic distance between the importing and exporting countries. This variable is a proxy for the transportation cost of the trade. $Emission\ intensity_{it}$ is the domestic emission intensity in our analysis to identify the carbon leakage effect on embodied emissions. $u_{ijt}$ is an error term, consisting of an individual country effect $\varepsilon_{ijt}$ and $v_{ijt}$, an idiosyncratic measurement error. $u_{ijt}$ represents the omitted impact of other causes.

In this model, the effect of tariff policy on environmental quality is captured by the use of the MFN applied weighted mean of tariff rates. The MFN tariff rates are weighted by the import shares of the product groups for each of these countries. For the hypothesis, we expect to have a negative relationship between overall tariff rate and embodied emissions in international trade. Higher tariff rates cause imported goods to be costlier to the domestic market, and reduce their demand and hence, emissions. The United Nations Statistical Division constructs international standard industrial classifications of all economic activities (United Nations Statistical Division 2008), and we use the classification for the consistency of industries globally. In a scenario analysis we focus on the increased tariff, no tariff change and decrease of tariff compared to the existing level of tariff imposed on sector-specific imports and exports. We predict the possible trend of embodied $CO_2$ emissions from the tariff reallocation scenario analysis.

### 2.2 Data

The analysis uses the disaggregated tariff and embodied $CO_2$ emissions data for panel regression. Embodied $CO_2$ emissions from imports between United States-China and MFN *ad valorem* tariff rates related to bilateral trade are used to conduct econometric analyses. Also, the gross domestic product (GDP), and distance between the trading countries is also considered, to identify the impact of the economy and geographic location on embodied $CO_2$ emissions, related to imports.

Calculating the embodied emissions becomes complex due to the need to enumerate the unique production systems in individual countries to a reasonable level of sector detail and to then link these to consumption systems through international trade data. The most common methodology for this type of analysis is a generalization of environmental input-output analysis (IOA) to a multiregional setting (Lenzen *et al* 2004). Imports of one country are related to production technologies from different regions of the world. The exporting economy also delivers import demands to other countries simultaneously. Thus, embodied import factors depend on the supply chain in the inter-industry demands. Therefore, different regions need to be considered for the supply path in the model. A multi-region input-output (MRIO) model can truly determine and distinguish the intermediate and final demand during trade (Wiedmann *et al* 2007). We use the Eora multiregional input-output (MRIO) table (Lenzen *et al* 2012, 2013) as a data source for some of the dependent and independent variables. The Eora MRIO table includes 187 countries, and each country has between 26 and 501 sectors, for a total 15,909 sectors. We followed Kanemoto et al., (2012) to decompose production-based emissions into consumption-based emissions and embodied emissions in export and import, using the following equation:

$$\underbrace{F_j^s}_{\text{production}} = \sum_r f_i^r \left[ \underbrace{\sum_{iu} L_{ij}^{ru}\, y_j^{us}}_{\text{consumption}} - \underbrace{\sum_{iu \neq s} L_{ij}^{ru}\, y_j^{us}}_{\text{imports}} + \underbrace{\sum_{iu \neq u} L_{ij}^{rs}\, y_j^{su}}_{\text{exports}} \right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where $f$ is factor intensities (i.e., carbon emissions divided by gross output), $L$ is the Leontief inverse, $y$ is final demand, and $i$ and $j$ are sector origin and destination. The exports term covers the factor used in region $r$ required to produce final goods in $s$, which are then sold by $s$ to $t$; the imports term covers factor to use in region $r$ required to produce final goods in $t$, which are then sold by $t$ to $s$.

We begin with the TRAINS data on bilateral trade from the United Nations Statistical division. We define manufacturing sectors as ISIC trade code 3 and mining sectors as ISIC trade code 2. Tariff data are obtained from the United Nation Conference on Trade and Development (UNCTAD) TRAINS database and completed when necessary from the World Trade Organization database. We obtain the UNCTAD TRAINS weighted tariff rate data, which is the average of the most favored nation tariff rates weighted by the product import shares corresponding to each partner country. We aggregate the MFN tariff to the 2 digit ISIC Revision 2 level by taking the weighted average of tariff lines within each ISIC code.

## 3. Result

The embodied $CO_2$ emissions from manufacturing sectors between United States-China trade are the sum of the direct and indirect $CO_2$ emissions. Our estimates using *Equation (3)* are shown in *Table 1*. The empirical results identify the impact of MFN tariffs on embodied $CO_2$ emissions from manufacturing sector trade. Our gravity model of embodied emissions allows us to identify the impact of the GDP of the trading partners on embodied $CO_2$ emissions. We also identify the impact of the distance between trading countries, population and emission intensity of the importing country on $CO_2$ embodied emissions.

In the following analysis, the statistically significant positive sign indicates that further tariff increase between United States-China manufacturing sectors trade can increase the $CO_2$ embodied emissions for the sectors. The amount of $CO_2$ embodied in imports of manufactured goods for the United States and China is also determined by the size of the economy and by its distance. We identified that the embodied $CO_2$ emissions have a positive relationship with the GDP size of the importing and exporting countries. The capacity of manufacturing products and purchasing capability of the imports can be reflected by GDP. The higher the GDP, the greater the potential of demand and supply of tradable goods.

The embodied emission intensity of the importing country represents the environmental regulation policy efficiency. We noticed that as an importer of manufacturing goods, emission intensity in the United States and China have a positive impact on embodied CO2 emissions. Which justify that if trading partners have less environmental regulation, they keep increasing the embodied CO2 emissions by bilateral trade. We also noticed that the increasing population of the importing country have a positive impact on the embodied $CO_2$ emission from manufacturing sectors. This finding support that large population creates additional demand on importing manufacturing goods which also guided an increasing level of embodied emissions.

Table 1: Impact of MFN tariffs on embodied $CO_2$ emissions for the import of manufacturing goods between trade in the United States and China.

| | $CO_2$ embodied emissions (Tons) from manufacturing sector | |
|---|---|---|
| VARIABLES | FE | RE |
| *Tariff (%)* | 3,134*** | 3,054*** |
| | (1,205) | (1,180) |
| *Embodied Emission intensity* | 2.308*** | 2.346*** |
| | (0.223) | (0.222) |
| *$GDP_i \times GDP_j$ (trillions)* | 1,682*** | 1,706*** |
| | (284.6) | (283.8) |
| *Population (millions)* | 926.28*** | 905.52*** |
| | (271.22) | (268.49) |
| *Distance (thousand Km)* | | 1,643,308** |
| | | (732,050) |
| *Constant* | -688,882*** | -1.874e+07** |
| | (206,350) | (8246,488) |
| *Observations* | 288 | 288 |
| *R Squared* | 0.57 | 0.68 |
| *Country fixed effect* | Yes | No |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## 4. Conclusion

The empirical results of our paper are three-fold. First, the trade battle between the United States-China induced tariff increase in manufacturing sectors significantly increase the $CO_2$ embodied emissions. Second, the GDP increase of the United States and China significantly impact on embodied $CO_2$ emissions between the bilateral trade. Finally, the emission intensity of the importer significantly affects embodied $CO_2$ emissions. Additionally, when the distance between the United States and China as well as the large population guide higher $CO_2$ embodied emissions.

Tariff reform is a popular tool for international trade and the economic welfare of countries. Incorporating the environmental impacts for trade liberalization by tariff reduction presents significant challenges for policymakers. MFN tariff reduction provides more favorable access and benefits to unlimited trade volumes. The analysis identifies the impact of tariff increase due to trade battle on the embodiment of $CO_2$ in imports. The findings would guide policymakers to understand the impact of trade battle on embodied emissions. We are now doing scenario analysis to identify the impact of trade battle on future embodied emissions.

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