Implications of U.S. and China trade in the Green House Gases generation, 2000-2010

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Abstract

In the last two decades, two elements have shown upward growth rates, Green House Gases (GHG) emissions and trade. In a globalized environment, several countries, especially developing countries, have bought low cost inputs, which at the same time are high pollution inputs. The later allow them to increase their competitiveness in commerce and to become suppliers of certain types of goods.

In this paper we verify which are the sectors and countries that have increased their dependency of foreign inputs to export and at the same time have increased their GHG emissions to export, with the objective of identifying the higher polluting sectors due to the acquisition of foreign inputs with low levels of environmental efficiency. This is achieved through the use of value added trade matrices and GHGs for export matrices, considering the methodologies proposed by UNCTAD and De Backer and Miroudot (2012) in the first case, and an adaptation for GHGs of the proposal for employment matrices of Dominguez, et al. (2008).

Resumen

En las últimas dos décadas, dos elementos han mostrado una tendencia creciente, las emisiones de Gases de Efecto Invernadero (GEI) y el nivel de comercio. En el entorno globalizado, algunos países, especialmente en desarrollo, han adquirido insumos a bajos costos pero altamente contaminantes, lo que les ha permitido ser más competitivos en el comercio y ser proveedores de cierto tipo de bienes.

En este artículo verificamos cuáles son los sectores y países que han incrementado su dependencia de insumos extranjeros para exportar y a su vez aumentado su emisión de GEI para exportar, con el objetivo de identificar los sectores contaminantes debido a la adquisición de insumos extranjeros poco eficientes en materia ambiental. Lo anterior mediante el uso de matrices de comercio en valor agregado y matrices de GEI para exportar, considerando las metodologías propuestas por UNCTAD y De Backer y Miroudot (2012) en el primer caso y una adaptación para gases de la metodología propuesta por Domínguez, et al. (2008) para matrices de empleo.

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Introduction

In the last two decades international trade and emissions of greenhouse gases (GHGs) [3] have gained increasing interest due to changes in the structure of trade and environmental implications. This because of its high growth levels and the implications of the first in global economic situation and the second in the increase of global temperatures.

The growth of international trade has benefited from the increase of agreements that lowering trade barriers, the increase of transportation and logistics services, the development of information technologies and telecommunications, especially the geographical fragmentation of production processes, promoted by the proliferation of large multinational corporations.

In the context of globalization, one of the principal characteristics of large corporate is the diversification of both providers and the location of its production plants. Which makes clear that nowadays the global production chains lead behind a generation process of value of a good, diversified in several countries, the above is known as global value chains (GVC).

This process has proliferated especially in developing countries that provide ad hoc conditions, such as tax incentives and cheap labor. However, profits for these companies not only occur in these two aspects, also in many developing countries, environmental regulations are less stringent.

The transfer of production activities from developed countries with stricter environmental standards[4] to countries with less environmental regulation is known as the pollution heaven hypothesis (see Kornerup, et al 2008, Zhou and Kojima, 2010). This process has sparked an international debate because emissions represent a global effect, regardless of the place where they are generated.

The generation and regulation of emissions is very important in many ways,[5] because the GHG generation is associated with the production, distribution and consumption of goods and services, so its relation with trade is up most important.

On the other hand, in the international trade context, from the beginning of this century, have increased efforts by countries and international agencies to generate information to enable study with greater certainty trade flows.

For this, we have generated input-output matrices in their trade expanded version known as multi-regional input-output matrices (MRIO) such as: WIOD, EORA, JETHRO, EXIOPOL, GTAP, etc, which have allowed to use more accurate methodologies for both generation

[3] GHGs are the main elements causes of climate change together with the concentration of water vapor

[4] Especially those countries with environmental commitments such as the Kyoto Protocol.

[5] Global warming, generated mainly by the accumulation of greenhouse gases in the atmosphere, according to reports from international informs such as the Intergovernmental Panel on Climate Change (IPCC), has devastating consequences for economies, affecting land use of crop, the seas, rivers, desertification and generate various areas of the planet, such as the Amazon basin.

GHG and value added in trade, because they allow to see the direct and indirect effects that occur in the exchange and not assume that all countries have the same technology[6].

With respect on the impact of trade on GHG generation, before, studies, due to the difficulty of building a MRIO, used only input-output matrices nationals. The purpose of these studies, using the methodology known as " pollution embodied in trade " was to understand the behavior of GHGs associated with trade, especially considering the "emissions embodied in bilateral trade", i.e., an analysis of the GHG embodied in exports and imports.

However, this approach has two limitations; the first is that it can only capture the direct effects to shocks in the final demand of the country of study, i.e, does not consider the indirect demand from other countries involved in the generation of a product; the second point, which has a sequence with the first, is that the methodology assumes that the rest of the countries with which trade have the same technology that the country of study.

Overall, the use of a MRIO allow to observe the direct and indirect effects associated with the generation of a good or service. Likewise, each country in a MRIO, has its own technology. This kind of matrices allow to develop impact analysis for both domestic consumption and exports and imports, and associate them with variables such as CO2, flows of raw materials, energy, land use change, among others[7].

Most of the work reviewed using MRIO to study the areas of value added and emissions associated with trade, consider only one of the two variables, i.e, there are studied separately. However, some authors like Wilting (2008) searched for this type of analysis for trade flows and emissions in the Netherlands (Wiedman, 2009. p. 214) to present a comparison in parallel.

Studying through MRIO flows of added value and GHG emissions associated with trade, it is possible to identify where the two flows come from, what is their composition within the trade of each country and which countries are demanding goods produced. This aspect can not be seen separately because the generation of emissions is a process naturally associated to production.

For the above reasons it is possible to establish the following questions: Which are the countries and / or sectors that have increased trade at the expense of increasing GHG emissions? do these same countries have increased their generation of value added?

The objective of this work is to identify which sectors and / or trade partners of the United States and China have increased their exports using imported inputs and simultaneously increased their generation of GHGs. This under the assumption that some countries,

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[6] Given the difficulty of having a MRIO, the use of input-output matrices (IOT) to estimate the effects of trade and GHG generation, boomed. However, according to Xu and Dietzenbacher, 2014, studies based on regional matrices allow more appropriate approaches for quantifying emissions in trade (EET). This because methodologies MIP-based or bilateral trade of input-output, imported inputs are assumed with a technology and emissions similar to the country-based.

[7]Kornerup, et al.(2008), mention that this type of analysis is analogous to the methodology of " life cycle assessment".

especially developing countries, have purchase highly pollution inputs, allowing these countries to increase their competitiveness in international trade and become suppliers of certain types of goods at the expense of increasing their emissions and at the expense of introducing less own value-added in the products.

The database considers the use of 3 MRIO for a sample of countries with which the United States and China have a high volume of trade and are also highly GHG generators.

The methodology used in the field of pollution is based on the proposed use of employment by Domínguez et al. (2012) applied to emissions. Additionally we generate a value added to export matrix to identify the use of domestic and imported inputs and the increase or decrease of domestic value added in exports of countries.

Empirical record of trade and GHGs are presented in the first part of the document; in the second it is described the methodology and base; in the third part are discussed the results of GHG emissions in trade *vs* the trade in value added; in the fourth part are present the findings that address the research questions of this study.

1.- Empirical evidence of trade and greenhouse gases generation

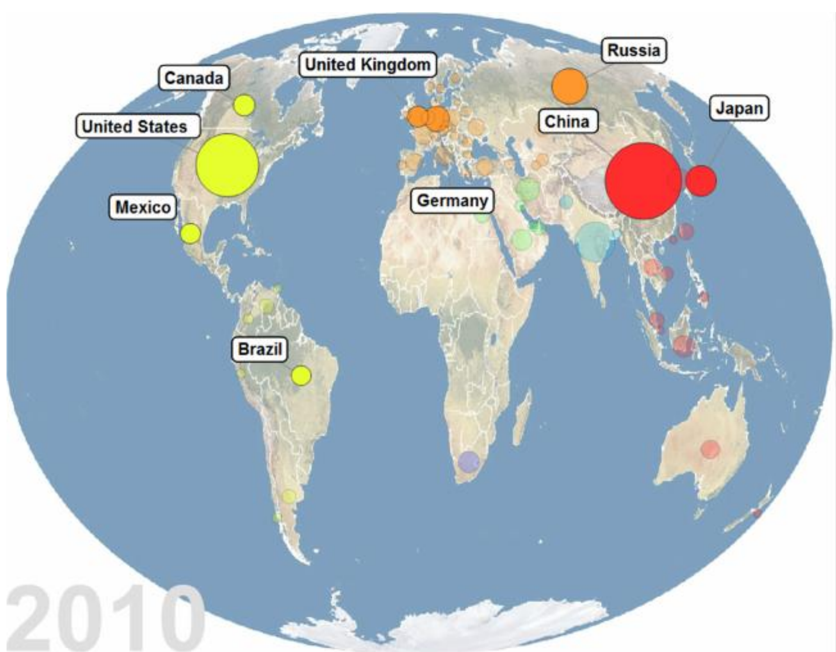
Literature on trade and greenhouse gases highlights the importance of developed countries and China in the global context. However, studies tend to build on the latter country compared to the United States for various aspects. On the one hand because of the historical importance of the North American country in the production and consumption of goods and services, and the generation of greenhouse gases and on the other, by the recent establishment of China as one of the leading suppliers in the international trade and as one of the more GHGs generating countries.

Due to the fact that GHG generation is associated with the production, and a decrease in emissions could represent less production and, therefore, lower economic growth, expectations for its diminishment have generated many debates.

In general, to argue about which countries should reduce their emissions, it can be by two questions: what are the countries that generate more emissions now, and what countries have generated more emissions over time?

Summarizing, we can answer these questions using the maps 1 and 2 below. Map 1 shows that of the countries studied, China is producing more emissions per year by 2010[8], followed by the U.S., Russia and Japan, respectively.

Map 1. Annual emissions in thousands of tonnes of CO2, selected countries, 2010.

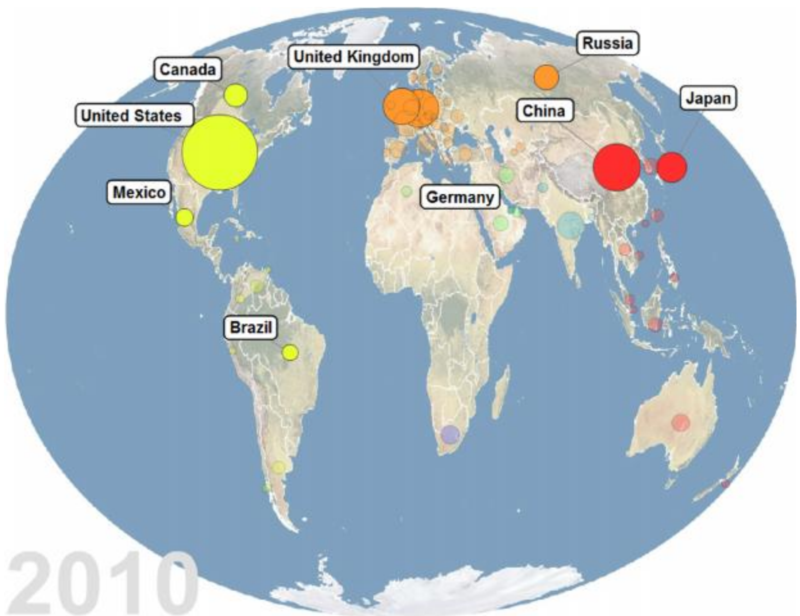


Source: Gapminderwolrd

[8]The data used in this article are all GHGs, nevertheless, about 72% of greenhouse gases are CO2 (Kornerup et al., 2008), so the data presented on maps are significant in GHG emissions.

Nevertheless, in Map 2 it can be seen that the cumulative effect of such emissions, considering the last 2 centuries[9], it is clear the dominance of the United States, followed by China and Germany. Note that these three countries are control the economy of each of their regions and largely global trade.

Map 2. Accumulated emissions in tons of CO2 from 1760 to 2010, Selected Countries



Source: Gapminderworld

In the commercial area, according to World Bank data, only the U.S. and China together account for about 24% of world exports of goods and services (12% and 12% each), with annual change average rates for 2000-2011 of 6% and 20% respectively.

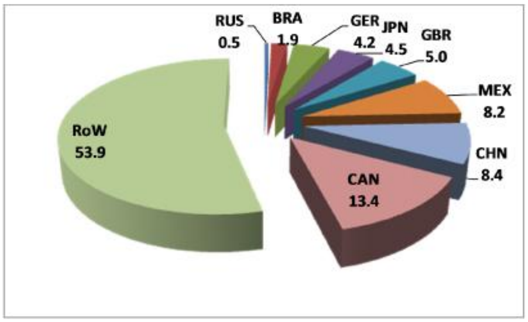
Whereas previous data of trade flows and GHG generation, a deeper analysis of these two countries is of special interest. In the context of global production chains, these data still not clarify the trade flows and GHG generation; however, they allow us to focus on the two most important countries in these areas: U.S. and China.

In Figure 1 we can see that Canada, Mexico and China are the major recipients of U.S. exports, while the latter is the largest recipient of Chinese exports. However, the above does not differentiate between exports of final goods or inputs, nor how much value added aggregate each country to their exports, but suggests that part of the emissions generated by the production of China can be explained by the U.S. consumption, we will try to clarify this situation in section 3.

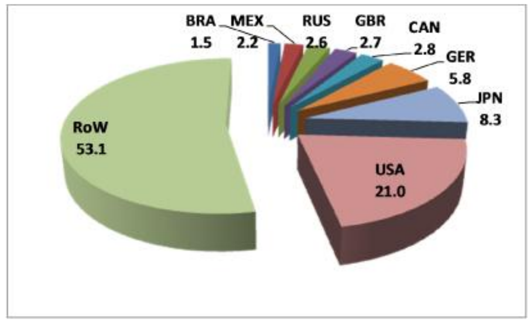
Figure 1. Distribution of exports from the U.S. and China by country of destination Selected Countries, 2010

[9] Significant increase for developed countries are post-1970, while in China are after 2000

U.S



China



Source: Authors' calculations based on data from the WIOD

2.- Methodology and Database

The database used is for the multi-regional matrices of the World Input-Output Data base (WIOD) covering the years 2000, 2005 and 2010, of which we extract 9 countries and other countries are left as "rest of world". Vectors of GHG emissions are reported in CO2 equivalent units from Eora-UNCTAD database[10].

The methodologies are based on the standard relation for input-output analysis to the entire economic system (Miller and Blair, 2009, p. 20)

$$\boldsymbol{Z} * \boldsymbol{i} + \boldsymbol{f} = \boldsymbol{x} \qquad \textbf{1}$$

Where:

X: is the inter-industrial transactions matrix

i: identity vector

f: final demand vector

x: total output vector; vectors are written as columns

2.1 Matrix of GHG in exports

We start from the methodology Domínguez et al. (2012) which proposed an alternative way to estimation and analysis of employment based on final demand shocks. In this paper we use

[10]To standardize the data in comparable sectors, are reduced MRIO sectors of the WIOD for 3 years, as well as emissions vectors of Eora-UNCTAD in a new classification of 23 sectors. The names of the sectors used in the research can be found in the annexes of the document.

the same approach, but instead of considering employment, we use a vector measured in CO2e GHG[11].

Of the basic expression (Equation 1), by a vector "g" of GHG is obtained L = $\widehat{gx}^{-1}$, where ^ means that the vectors have been transformed in diagonal matrices, and represents a coefficient matrix of the units of GHG generated by unit of gross output.

When each member of (1) is multiplied by L, to maintain the equality, we obtain

$$\widehat{gx}^{-1}(\boldsymbol{X} * \boldsymbol{I} + \boldsymbol{f}) = \widehat{gx}^{-1}\boldsymbol{x} \qquad \mathbf{2}$$

or the same

$$\boldsymbol{LX} * \boldsymbol{I} + \boldsymbol{Lf} = \widehat{gx}^{-1}\widehat{\boldsymbol{x}} \qquad \mathbf{3}$$

Due that $\widehat{\boldsymbol{x}}^{-1}\boldsymbol{x} = \boldsymbol{I}$ and $\widehat{\boldsymbol{g}}^{-1}\widehat{\boldsymbol{g}} = \boldsymbol{i}$

We can rewrite the expression (3) as:

$$\boldsymbol{LX} * \widehat{\boldsymbol{g}}^{-1}\widehat{\boldsymbol{g}} + \boldsymbol{Lf} = \boldsymbol{gI} \qquad 4$$

Al reordenar y despejar $\boldsymbol{Lf}$:

$$\boldsymbol{Lf} = \widehat{\boldsymbol{g}}\boldsymbol{I} - \boldsymbol{LX} * \widehat{\boldsymbol{g}}^{-1}\widehat{\boldsymbol{g}} \qquad 5$$

$$\boldsymbol{Lf} = (\boldsymbol{I} - \boldsymbol{LX} * \widehat{\boldsymbol{g}}^{-1})\widehat{\boldsymbol{g}} \qquad 6$$

Isolating $\widehat{\boldsymbol{g}}$ as a diagonalized vector now called G, which will now be our GHG emissions vector:

$$(\boldsymbol{I} - \boldsymbol{LX} * \widehat{\boldsymbol{g}}^{-1})^{-1}\boldsymbol{Lf} = \widehat{\boldsymbol{g}} = \boldsymbol{G} \qquad 7$$

For the result of 7 be a diagonal matrix, **f** must be a diagonal vector of final demand

If we define E = $LX * \widehat{g}^{-1}$

Then we can rewrite equation 7 as

$$(\boldsymbol{I} - \mathbf{E})^{-1}\boldsymbol{Lf} = \boldsymbol{G} \qquad 8$$

Where $(\mathrm{I} - \mathrm{E})^{-1}$, when we use both L and F in matrix form (diagonal matrix) it allows to generate a matrix of direct and indirect GHG coefficients "G".

This expression is similar to the orthodox way to get a matrix of emissions using the following equation:

$$\widehat{\boldsymbol{g}}(\boldsymbol{I} - \boldsymbol{A})^{-1}\widehat{\boldsymbol{f}} = \boldsymbol{G} = (\boldsymbol{I} - \mathbf{E})^{-1}\boldsymbol{LF} \qquad 9$$

[11]The vector of GHG emissions in CO2eq includes the effect on the generation of CO2 derived from land use change and deforestation according to UNCTAD data-Eora, downloaded from: wolrdmrio.com/maindataset v199.74

The virtue of this alternative approach is the generation matrix similar to the Leontief inverse, since:

$$(\boldsymbol{I} - \mathrm{E})^{-\mathbf{1}} = L * (\boldsymbol{I} - A)^{-\mathbf{1}} * (\boldsymbol{L})^{-\mathbf{1}} \qquad \mathbf{10}$$

2.2 Matrix of Value added to export

The generation the matrix of value added to export matrix or trade in value added matrix (TIVA), has its origins, like the matrix of GHG to export in the standard input-output relation.

In this standard relation, by dividing the elements of the matrix of inter-industry transactions between the Total Output from every sector of destination of inputs, allows us to obtain the technical coefficient matrix A that represents the amount of inputs of each sector required for the generation of a unit of product.

Therefore we can rewrite equation (1) as

$$\boldsymbol{Ax} + \boldsymbol{f} = \boldsymbol{x} \qquad \mathbf{11}$$

isolating $\boldsymbol{f}$

$$(\boldsymbol{I} - \boldsymbol{A})\boldsymbol{x} = \boldsymbol{f} \qquad \mathbf{12}$$

get $\boldsymbol{x}$

$$(\boldsymbol{I} - \boldsymbol{A})^{-\mathbf{1}}\boldsymbol{f} = \boldsymbol{x} \qquad \mathbf{13}$$

Following the report of UNCTAD (2013), the TIVA part of the same structure of equation (13), as the Leontief inverse distributes the direct and indirect effects, but this time in an international perspective, within a MRIO, so we can observe the value added in exports through:

$$\hat{\boldsymbol{v}}\,(\boldsymbol{I} - \boldsymbol{A})^{-\mathbf{1}}\hat{\boldsymbol{e}} = \boldsymbol{TradeinValueAddedMatrix}\ (\boldsymbol{TIVA}) \qquad \mathbf{14}$$

where: v = value added coefficients vector, resulting by dividing the value added of each sector by Total Output of each sector.

e = exports vector

Where each column contains the domestic value added and the foreign value added (corresponding to imported inputs) within the generation of exports of each country.

3.- GHG in trade vs VA in trade

The methodologies presented in the previous section allowed us to obtain two information flows, the first corresponding to the value added embodied in exports of each country, i.e, the origin of the inputs used to produce exports; second, GHG emissions associated to each country's exports. Likewise this information allows to identify the origin of inputs and emissions associated to these inputs, both foreign and domestic, that were used to generate exports.

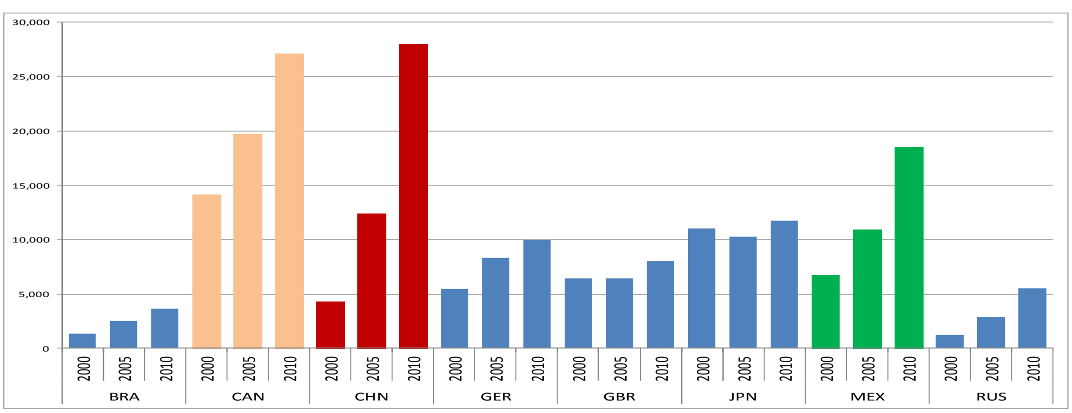
Both methods allow to clarify two situations, first solve the problem of double counting in trade, the second introducing a different outlook about the responsibility of emissions embodied in trade[12].

3.1 United States

According to estimates of foreign value-added embodied in exports from the United States, i.e, their input suppliers, Canada stands on one side and China and Mexico other, moving Japan and Germany. The case of China is exceptional increasing by more than 100% from 2005 to 2010, while Mexico and Canada maintain a constant growth rate between the periods analyzed (see Figure 1).

If we review the GHG emissions in the trade, we can compare the data with an additional filter. Figure 3, shows that GHGs associated with the inputs required by U.S. to produce exports of goods and services, comes from the same countries, Canada, China and Mexico. However, the growth of emissions associated with imports of these inputs by the United States is significant only for China and Mexico.

Figure 2. Foreign value-added embodied in exports from the United States



Source: Authors' calculations based on data from the WIOD.

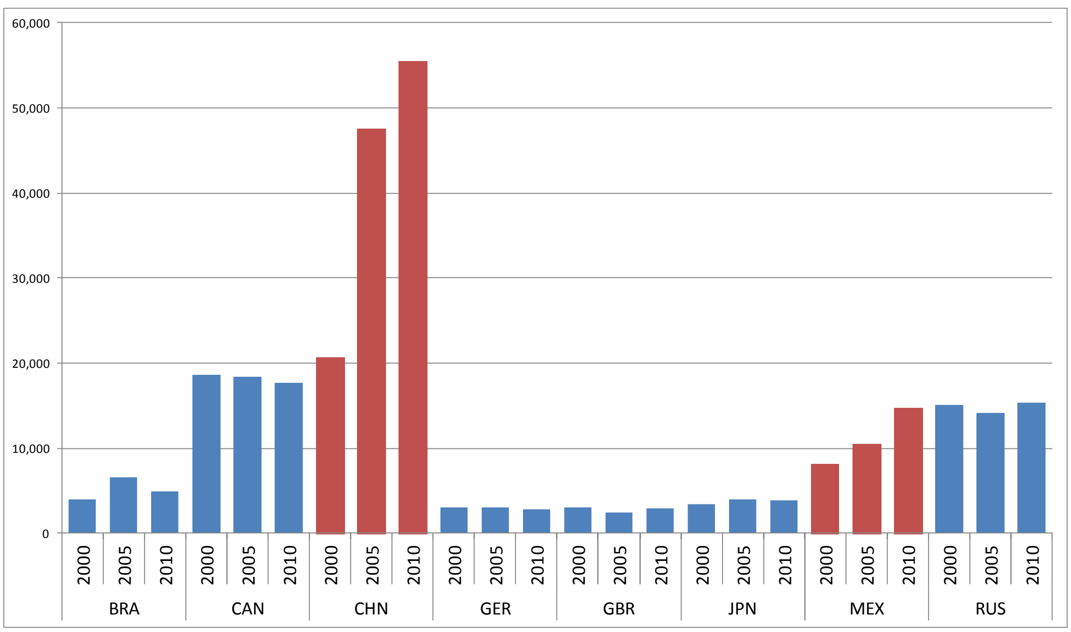
[12]Emission data of countries consider the emissions generated within the territory, so they assume that the country should acquire all the responsibility. But do not consider that in many cases these emissions are associated with external demand of goods produced within the country or the country of study itself generates emissions due to the demand of products made in other countries (Zhou y Kojima, 2010).

From before follows a fundamental aspect, if we compare the growth in value added of the inputs that China exports to the United States against the growth of emissions associated with the export of these inputs, we see that from 2000 to 2005, a greater emissions growth, while from 2005 to 2010, is higher growth in value added. This reflects that apparently during the second period the production of intermediate goods from China that are embodied into the production of U.S. exports, it is more efficient in environmental terms, i.e, China produce more of these inputs with less emissions generation.

Performing the same exercise with Mexico, both variables growth is similar, i.e, apparently both the input requirements and the technology used in the production of inputs from Mexico that are incorporated in U.S. exports has not changed in the study period.

Finally, Canada clearly shows a steady improvement during the period in terms of efficiency in production with respect to the generation of emissions, since the emissions associated with inputs from Canada to produce the U.S. exports are practically constant, indeed shows a slight decrease, while the value added from Canada for U.S. exports remained considerable growth rates.

Figure 3. GHG induced by the United States imported inputs for exports (million tons of CO2eq)

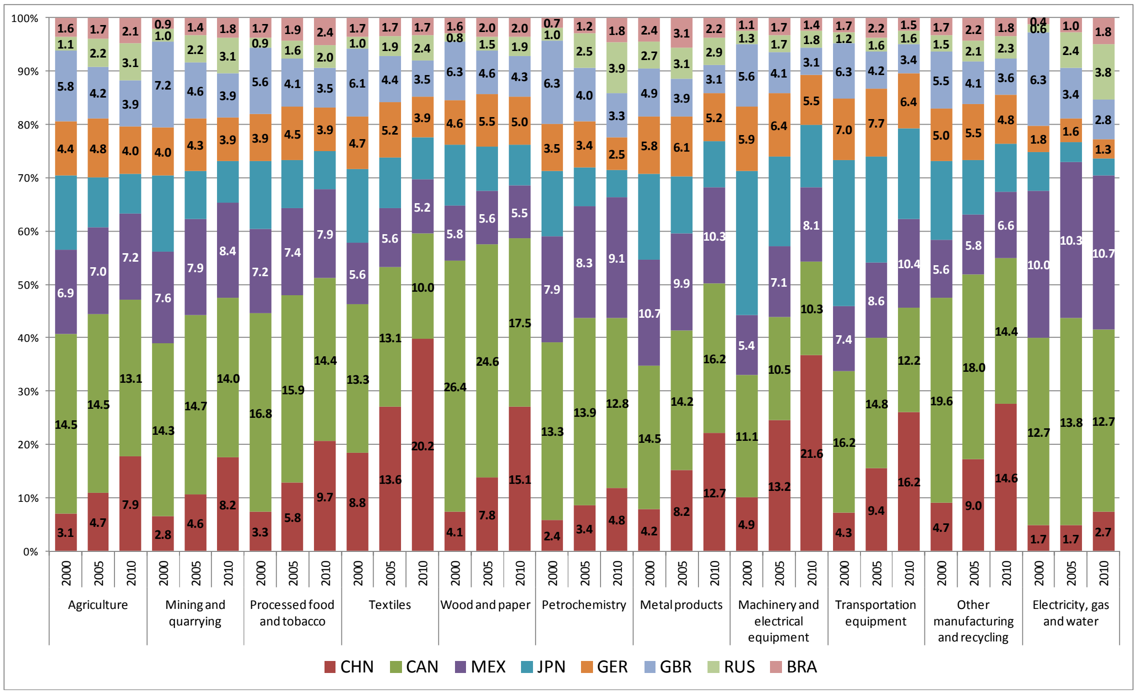


Source: Authors' calculations based on data from the WIOD and Eora-UNCTAD.

To validate the above assumptions is necessary to check that the inputs from both China and Mexico, come from the same industrial sectors, otherwise, our assumptions may be incorrect, and the effect could be due to exports from the United States 2005 and 2010 are derived from different sectors and therefore require inputs that are produced by other technology that can generate more or less GHG emissions.

A comparison between imported inputs to sectors producing goods for export from the United States is presented in Figures 4 and 5, for both value added embodied in its production and GHG embodied in its production[13].

Figure 4. Foreign value added in U.S. exports by country and sector of origin (percentages)



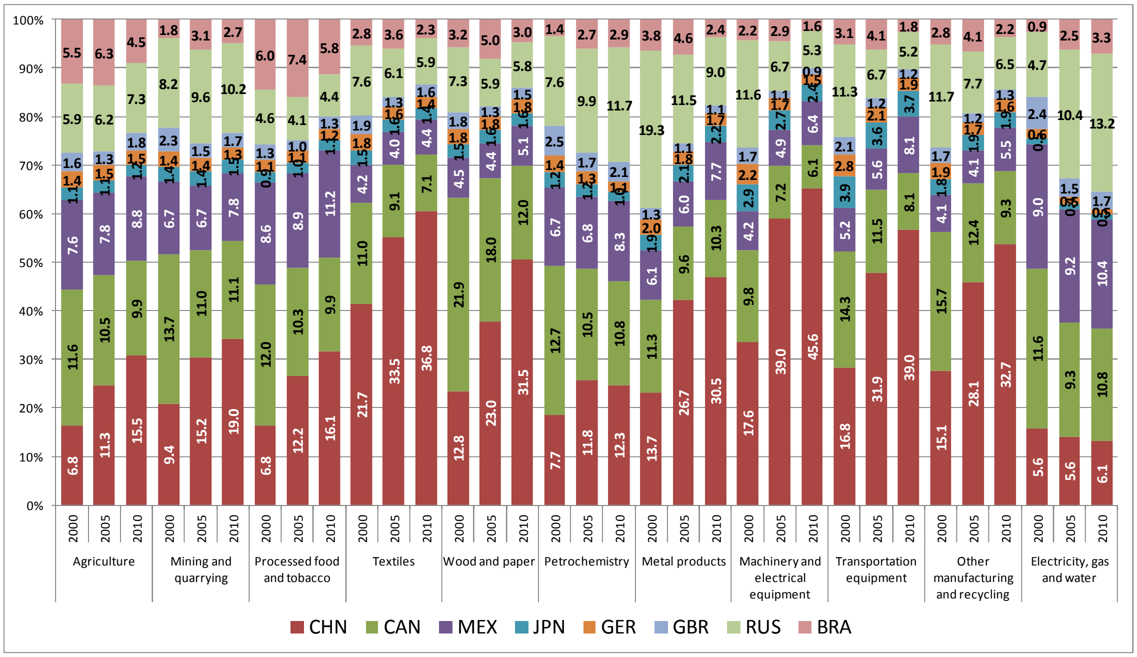
Source: Authors' calculations based on data from the 2010 WIOD.

It is observed that the largest increases in value added to export from China from 2005 to 2010 occurred in the sectors of textiles; wood and paper; machinery and electrical equipment; transport equipment, other manufacturing and recycling; as well as service sectors14. Comparing these sectors with data in terms of GHG generation of graph 5, shows that the increase is significantly lower, implying that production technologies for this period were modified for this sectors, so they are more efficient in terms of GHG generation. By observing these same sectors for the period 2000-2005, the largest increase was observed in emissions and lower in value added.

Figure 5. GHG emissions associated with U.S. exports by country and sector of origin (percentages)

[13] In this analysis we do not present service sectors due to the fact that they generate generally lower emissions, however, the results are presented in the Annex.

[14] Data for service export sectors are presented in Annex.



Source: Authors' calculations based on data from the WIOD and Eora-UNCTAD.

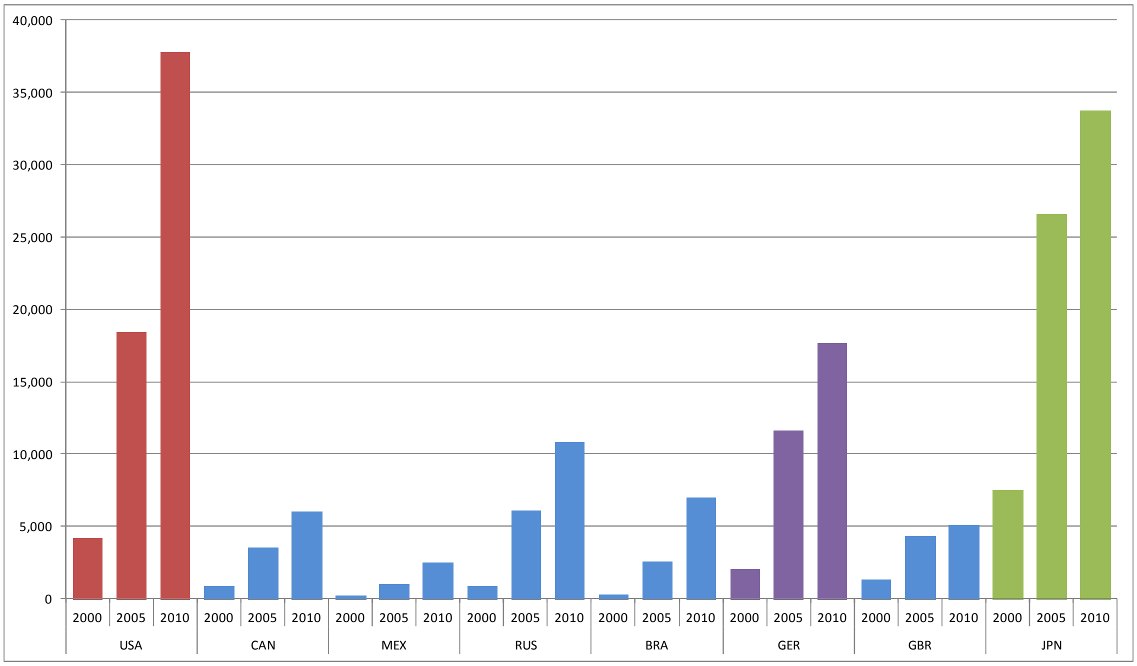
In the case of Mexico the result is reversed, 6 sectors are identified: petrochemical, metal products; machinery and equipment; transportation equipment; other manufacturing and recycling; electricity, gas and water. In these sectors a greater increase is observed in the GHG emissions that observed in value added for U.S. exports. That is, these sectors has sacrificed the environmental aspect to generate higher production.

This highlights even more when you consider that those 6 sectors have reduced their efficiency in terms of GHG emissions, accounting for 66% of Mexico's total exports.

3.2 China

As for the U.S., in Figure 6 we compare the foreign value-added embodied in Chinese exports to the emissions associated with those exports that appear in Figure 7. They note that importing of inputs from the United States, measured in value added, has been growing in the decade 2000-2010. From 2000-2005 the use of inputs from the United States quadrupled, while gas emissions associated with those inputs quintupled. While in 2005-2010 the value added from United States on China's exports continued its upward trend, GHG emissions remained almost constant. This would suppose an improvement in efficiency in environmental terms of the inputs from the United States.

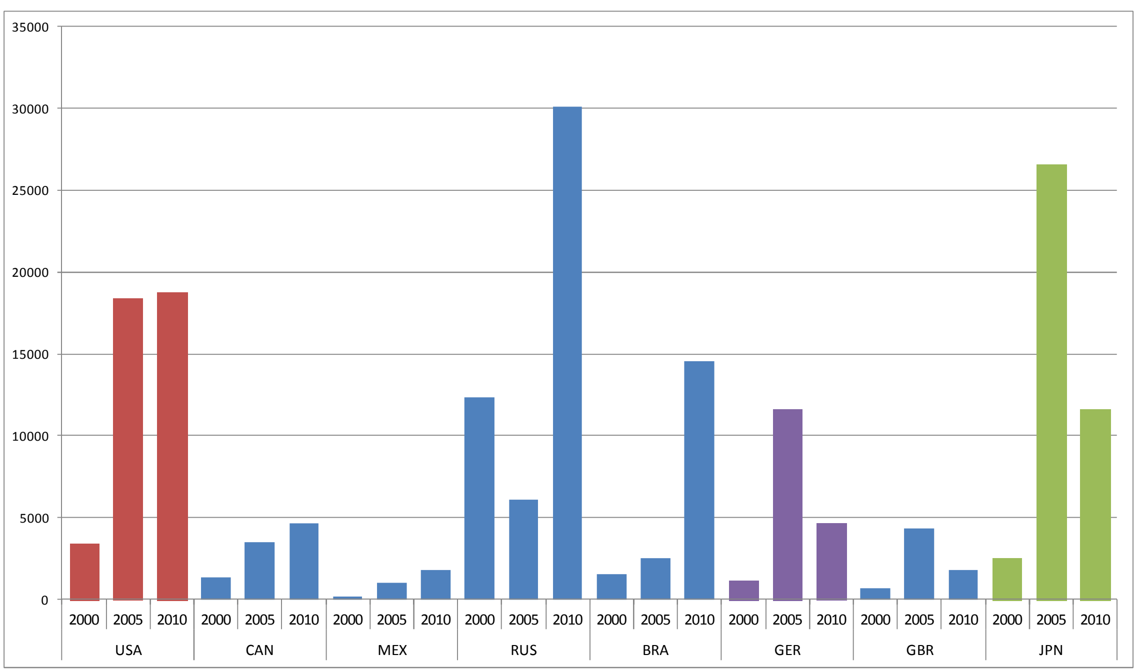
Figure 6. Foreign value added by country embodied in Chinese exports



Source: Authors' calculations based on data from the WIOD.

Japan, Germany and the UK show a similar behavior. Throughout the decade of study, the import of inputs from those countries embodied in China's exports maintained its upward trend. On the other hand, in the first five years the emission of GHG associated with these inputs grew considerably. Meanwhile, in the last five years, the emission was greatly reduced, suggesting, as in the United States, an improved in environmental efficiency in the production of inputs from these countries.

Figure 7. GHG induced by foreign inputs in China's exports (million tons of CO2eq)



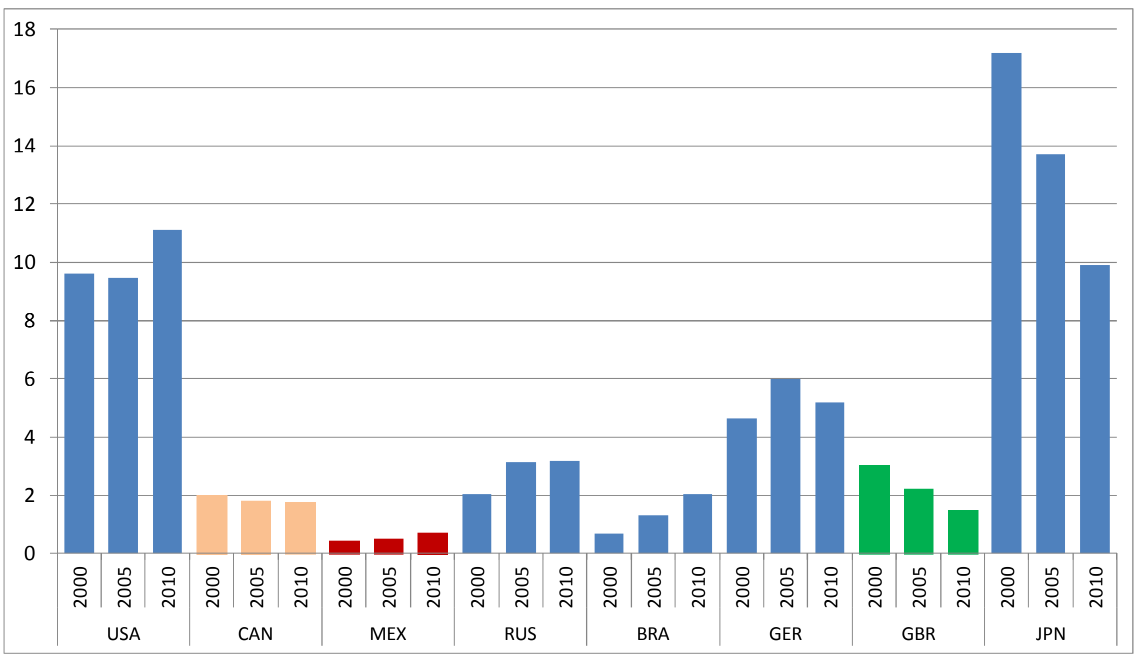
Source: Authors' calculations based on data from the WIOD and Eora-UNCTAD.

On the other hand Russia and Brazil show the reverse process during the period 2005 to 2010 presenting lower growth rates of its inputs embodied in China's exports, that the emissions associated with those inputs, which suggests a decrease in the environmental efficiency of the production of these inputs.

In the cases of Canada and Mexico the story is different. Both the value added from these countries incorporated in China's exports and GHG emissions associated with these inputs increased similarly. This suggests that the growth rate of exports of inputs from these countries were made at the cost of environmental degradation to remain constant.

Finally, in figures 8 and 9 the relative weight of foreign value-added and associated emissions are observed. Clearly, the United States, Mexico, Russia and Brazil have gained in their share of value added embodied in Chinese exports. Nonetheless, in the emissions side, the participation has only increased in the case of Mexico and Brazil.

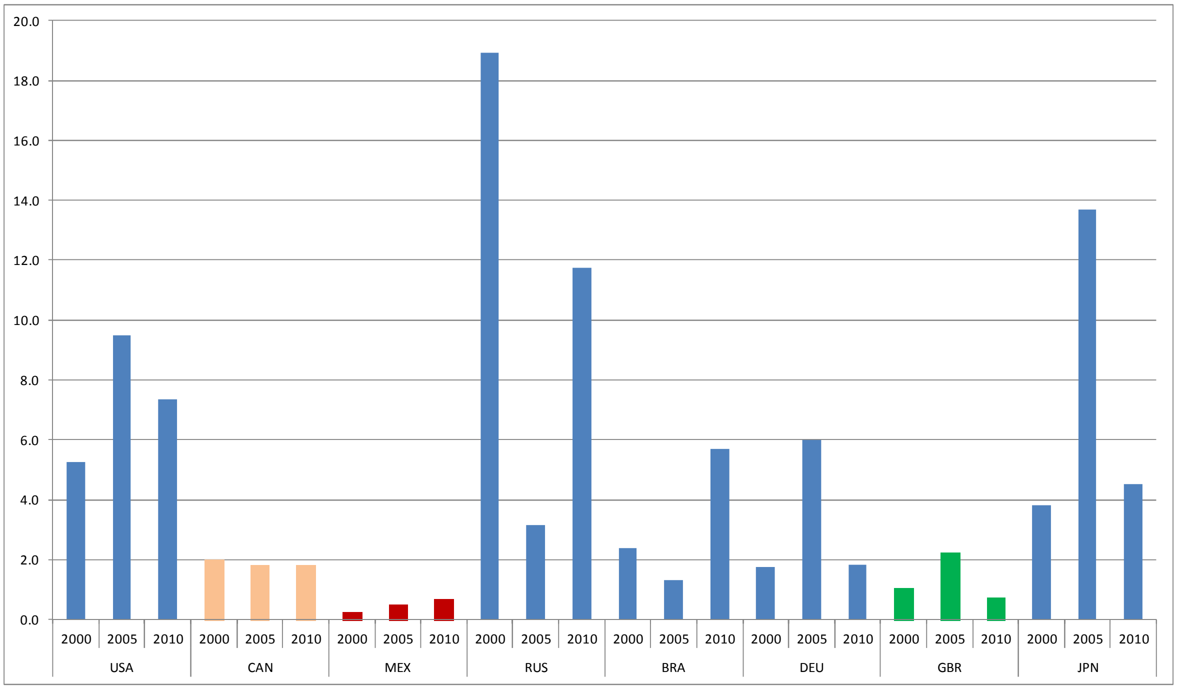
Figure 8. Foreign value added embodied in China's exports, as percentage of the total foreign value added



Source: Authors' calculations based on data from the WIOD.

This reinforces the idea that in order to satisfy the demand for inputs from China, developing countries have sacrificed the environmental aspect increasing more the amount of GHG emission than production. Meanwhile, developed countries like Japan, U.S. and Germany have increased their exports of products to China but less than or equal to their emissions rate.

Figure 9. GHG induced by China's exports, as percentage of total GHG induced



Source: Authors' calculations based on data from the WIOD and Eora-UNCTAD.

4.- Concluding remarks

For the generation of exports, the United States uses inputs mainly from Canada, Mexico and China. Note that the latter has increased its participation in the study period. However, the emissions generated associated with the use of these inputs allow to denote that the inputs from Canada are more environmentally efficient than those from Mexico and China.

For its part, China uses more inputs from Japan, the U.S. and Germany; however, in 2010 inputs from these three countries show a significant improvement in terms of environmental efficiency.

With respect to the exports flow and generation of total GHG by sector, U.S. exports in 2010, mainly in the sectors of petrochemicals, machinery and equipment, and transport equipment. While the sectors that generate more GHGs are petrochemical, machinery and equipment, transport equipment and metal products.

In 2010, China mainly exports in the sectors of textiles, petrochemicals, and machinery and equipment, and these themselves are the most polluting sectors.

Despite improvements in terms of environmental efficiency in the production of intermediate inputs from China for U.S. exports, these improvements are far from those presented by inputs from developed countries such as Japan, Germany, United Kingdom and Canada.

However, the results in terms of emissions for inputs from developing countries, including Brazil and Russia, considered in the BRICS group, are opposites.

Similar to that comparison made to Mexico and China, with respect to the influence of their inputs in U.S. exports, can prove that various sectors of Russia and Brazil have a higher rate of growth in emissions than in value added, implying an increase in the production of inputs at the expense of increased generation of GHG emissions. At this point highlights for Brazil sectors of food; and electricity, gas and water. While in Russia highlights the sector of electricity, gas and water. Note that Russia also presents the opposite case in the sectors of food; machinery and equipment; and transport equipment, which have shown a decrease in the share of emissions in U.S. exports.

This shows not only that the developing countries studied here generate a significant amount of emissions due to the demand of inputs by the U.S., also some of the sectors in these countries have increased their exports of inputs at the expense of becoming more inefficient in environmental terms, which validates the hypothesis of this work, especially in the case of Mexico, for its high dependence on the U.S. in terms of trade.

By studying both China and the United States it is clear that there is a generation of GHG emissions originated thanks to the demand for inputs between them, so that at least when considering "emissions in exports," the responsibility for the generation of GHG emissions is shared.

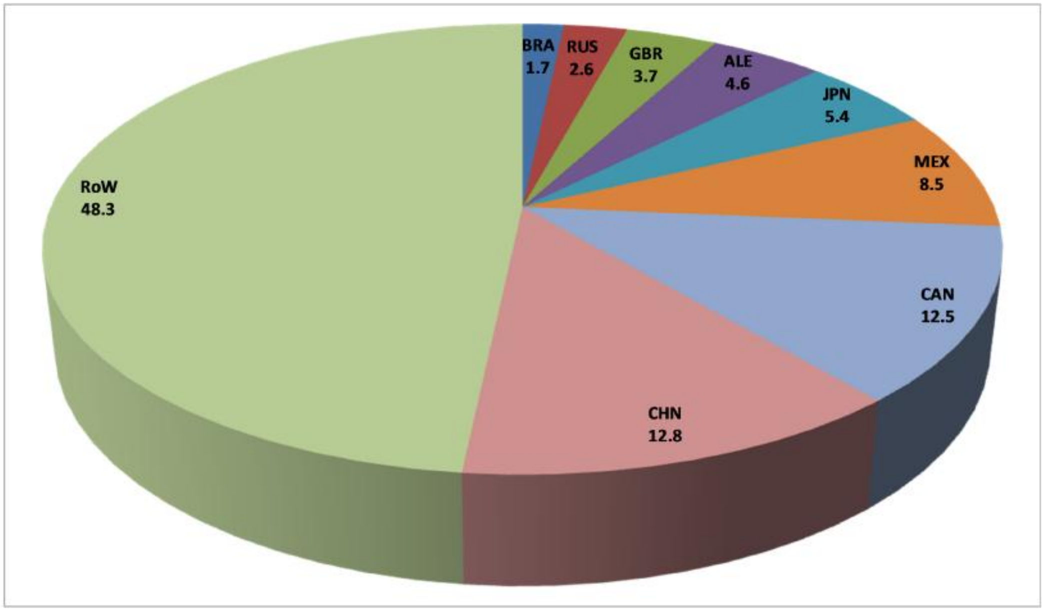
Finally, although the first part of this research shows that total U.S. exports are mainly exported to Canada, China and Mexico, in the second part shows that imports of inputs for export are mostly also of these three countries, demonstrating that the United States in a part of the production process buys inputs to these countries to export to them later more specialized inputs as well as final products and services.

5. Annex

Sectors

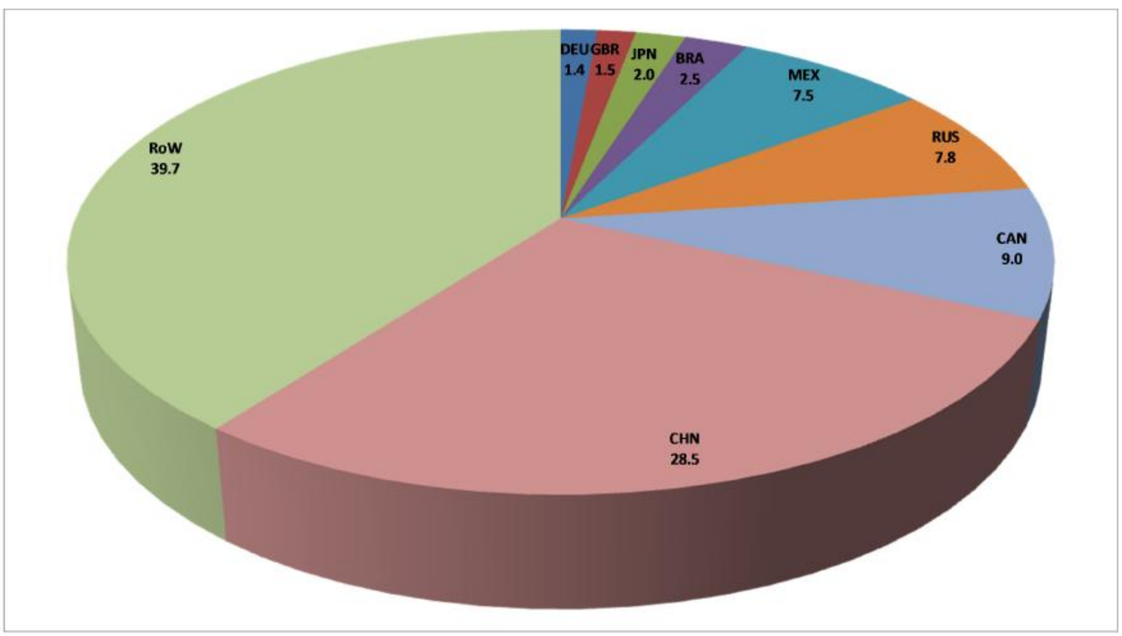
	Sector
1	Agriculture, hunting and fishing
2	Mining and quarrying
3	Processed food and tobacco
4	Textiles and leather products
5	Wood, paper and printing
6	Energy, chemical, plastics and non-metallic minerals
7	Basic metals and metal products
8	Machinery Nec., electrical and optical equipment
9	Transport equipment
10	Manufacturing Nec, recycling
11	Electricity generation and supply, gas and water supply
12	Construction
13	Maintenance, repair and retail sale of vehicles
14	Wholesale trade
15	Retail trade and repair of household goods
16	Hotels and restaurants
17	Transport services
18	Post and telecommunications
19	Financial intermediation and business activities
20	Public administration and defense
21	Education and health
22	Personal, social and community services
23	Household with employed persons

Figure 10. Foreign value added embodied in U.S. exports, 2010 (percentages)



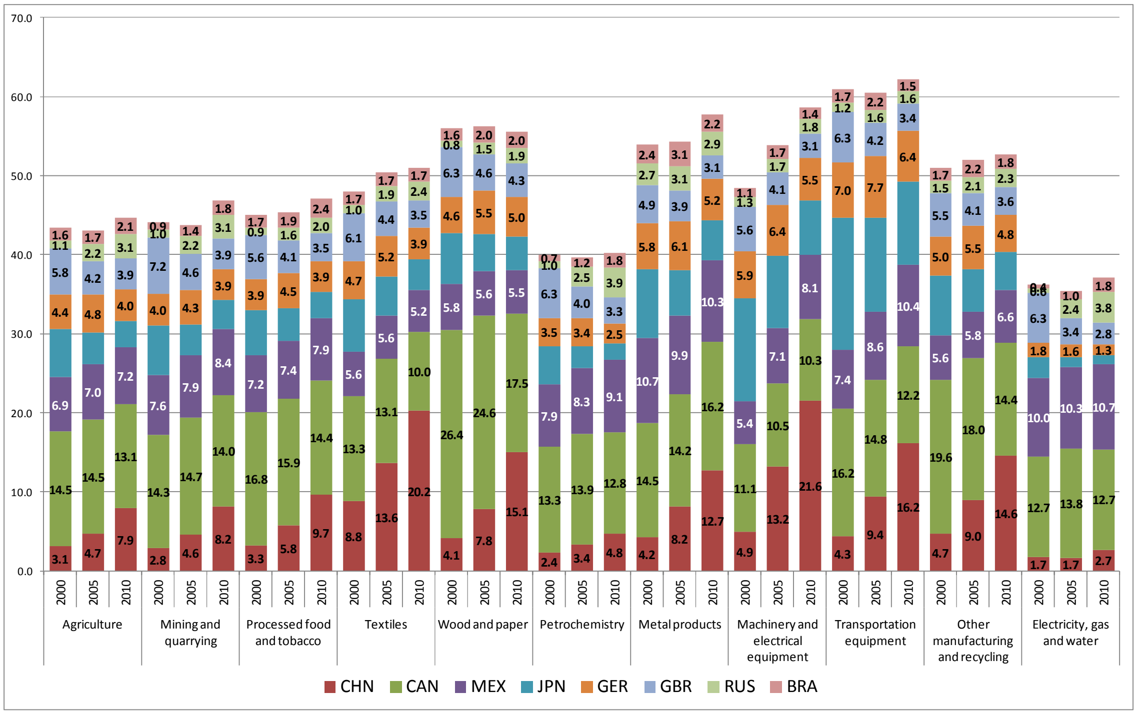
Source: Authors' calculations based on data from the WIOD.

Figure 11. GHG emissions by embodied in U.S. exports, 2010 (percentages)



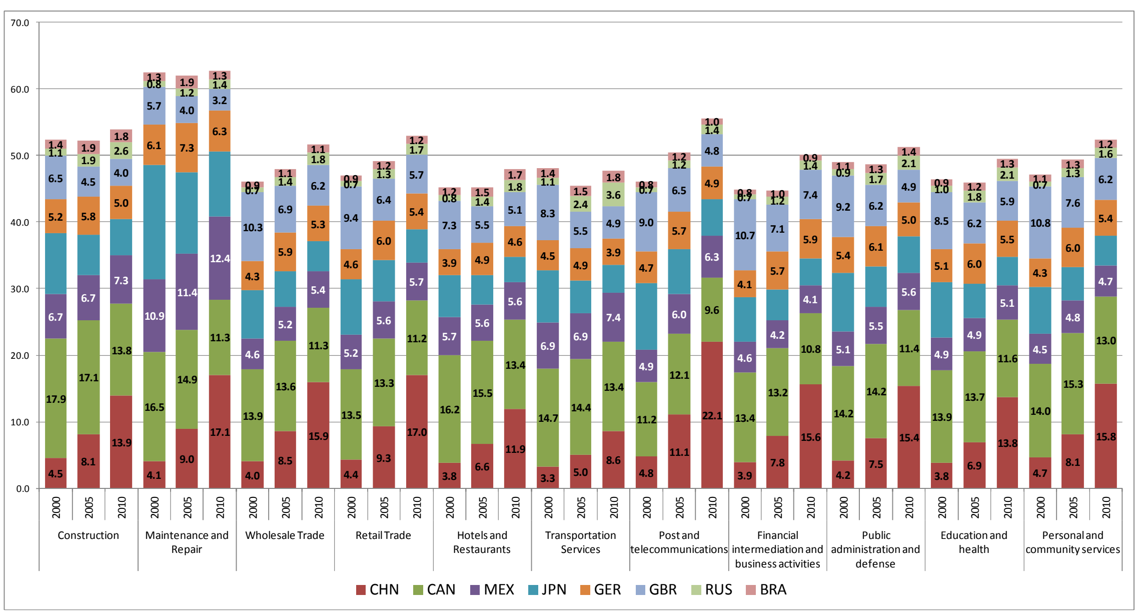
Source: Authors' calculations based on data from the WIOD and Eora-UNCTAD.

Figure 12. Foreign value added embodied in U.S. exports, by country and sector of origin (millions of dollars)



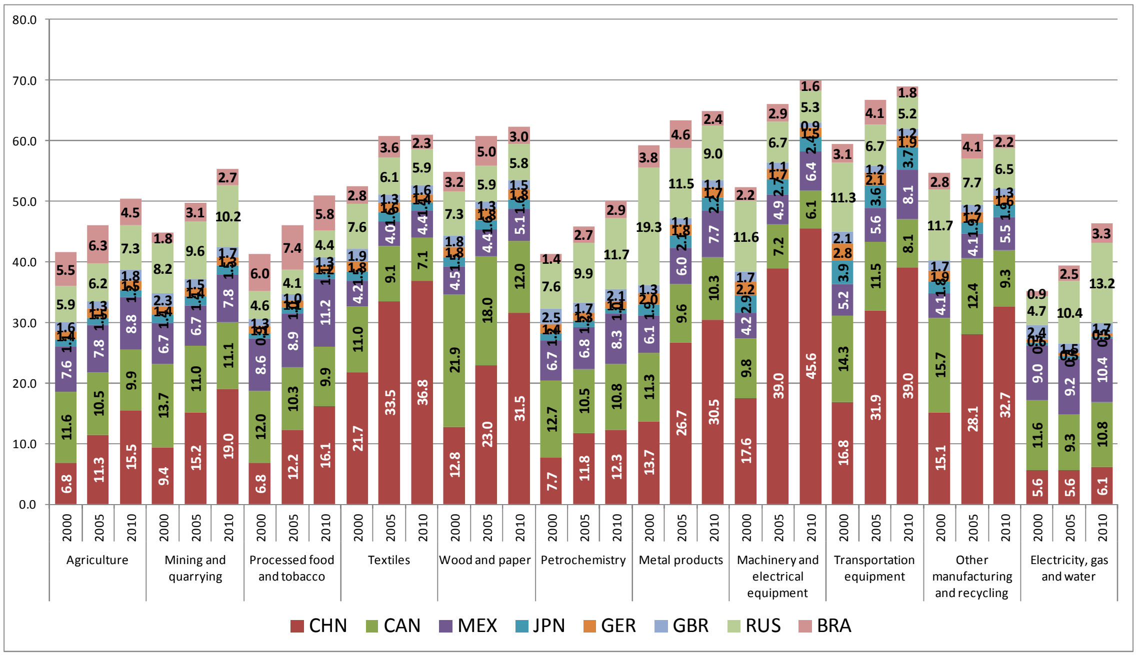
Source: Authors' calculations based on data from the WIOD.

Figure 13. Foreign value added embodied in U.S. exports, by country and sector of origin (millions of dollars)



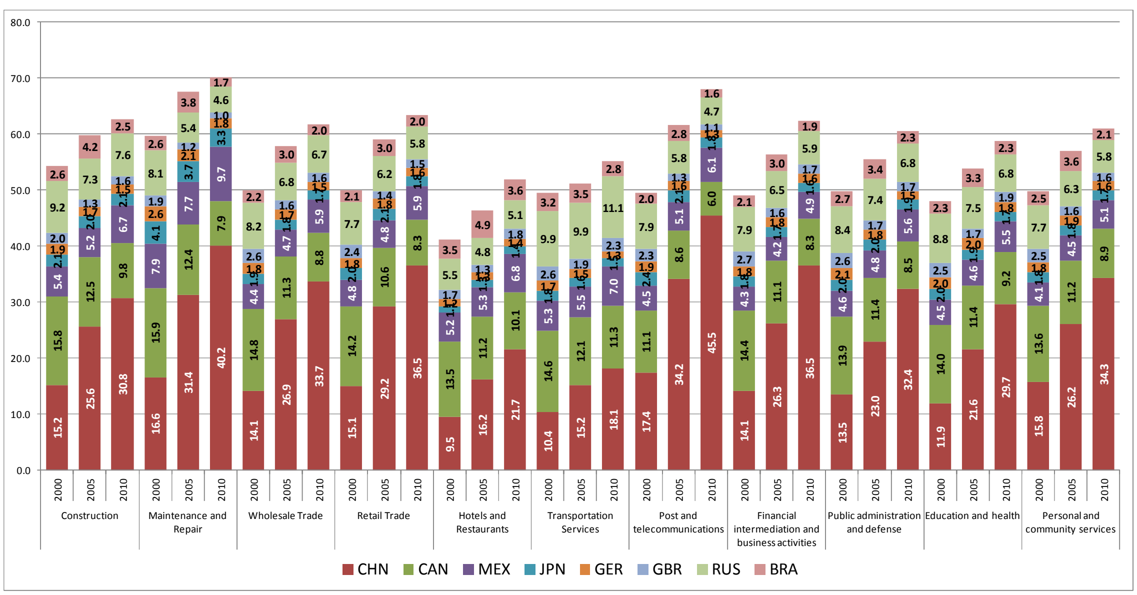
Source: Authors' calculations based on data from the 2010 WIOD.

Figure 14. GHG emissions embodied in U.S. exports, by country and sector of origin (Million tonnes of CO2 eq.)



Source: Authors' calculations based on data from the WIOD and Eora-UNCTAD.

Figure 15. GHG emissions embodied in U.S. exports, by country and sector of origin (Million tonnes of CO2eq.)



Source: Authors' calculations based on data from the WIOD and Eora-UNCTAD.

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