TOWARDS THE DECARBONISATION OF ECUADOR. A MULTI-SECTORAL AND MULTI-REGIONAL ANALYSIS OF ITS CARBON FOOTPRINT.

Rocío Román-Collado[a,b]; María Teresa Sanz-Díaz[a]; Cristian Germán Loja Pacheco[a]

[a] Universidad de Sevilla (Spain)[1]
[b] Universidad Autónoma de Chile (Chile)

ABSTRACT:
Globally, interest in the environment and its conservation is growing and primordial. In particular, CO_2 emissions generated by productive processes in a given territory in order to satisfy own and global consumption. Two types of responsibilities stand out, the producer's and the consumer's. Based on the Multi-regional Input-Output Methodology, this study determined Ecuador's responsibility in terms of CO_2 emissions, defining the economic sectors that have the greatest representation in these emissions, as well as establishing an assessment at the level of the Trade Balance. There has been a strong growth of Ecuador's Footprint of 145.26% from 2000 to 2015, with the transport and secondary sectors having the highest representation and the trade with the BRICS nations standing out. This results strengthens the need to foster a change in the population's and the public administrations' consumption patterns. So it is recommended that the authorities allocate part of the public budget to measures oriented to sustainable consumption.

KEYWORDS:
Multi-regional Input-Output Analysis, CO_2 Emissions, Carbon Footprint, Emissions Trade Balance, Ecuador, EORA

[1] Universidad de Sevilla. Facultad de Ciencias Económicas y Empresariales. Avda. Ramón y Cajal, 1. Sevilla. España.

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1. Introduction

Climate change has especially increased the vulnerability of Latin American countries in which, according to what the Corporación Andina de Fomento (Andean Development Corporation) (2014) considers, more than half of the region's population lives in a high or extreme risk of susceptibility to climate change. According to the projection of the Red Iberoamericana de Oficinas del Cambio Climático (Ibero-American Network of Climate Change Offices) (RIOCC 2020) this vulnerability is on the rise. There are various motives and sensitive focal points: the increase of the temperature and its impact on the reduction of the glaciers of the Andes and on the semi-arid zones of countries such as Chile or Brazil; the rise of the sea level and its effect on coastal countries, especially in large cities such as Buenos Aires or Rio de Janeiro; and the major frequency and intensity of cyclones, among others (Margulis 2016; RIOCC 2020).

The case of Ecuador stands out for its great natural heritage and a broad diversity of ecosystems, which are threatened by the consequences of meteorological disasters stemming from climate change (República de Ecuador 2017). Since the Constitution of 2008, Ecuador has launched numerous policy instruments referring to the mitigation of climate change and the preservation of the environment (República de Ecuador 2008). The first steps were taken by the Plan Nacional del Buen Vivir (National Plan for Well-being) (SENPLADES 2009 and 2013), after which a wide range of policies were articulated to attain climate-related aims. Nonetheless, during these first years most of these policies were part of abstract plans, independently approved by the different ministries and without there being sufficient coordination. This highlighted a lack of effectiveness and the inexistence of specific measures (Buenaño 2017; Jakob 2017).

In 2015 Ecuador presented the UN Framework Convention on Climate Change (UNFCCC) with the Contribución Tentativa Nacionalmente Determinada (Intended Nationally Determined Contribution) (INDC) of Ecuador. It is here seen that the country's central axis for the fight against climate change is decarbonisation, the change of the energy matrix and actions in the forestry sector. In 2016, the signing of the Paris Agreement in New York meant a great boost for the elaboration of a more specific legislative framework, such as is the case of the Código Orgánico Ambiental (The Environment Organic Code) (República de Ecuador 2017). This legislation has updated and supplemented that in force in Ecuador oriented at the management of climate change. Title VI of this Code is about sustainable consumption, proposing in various of its articles the fostering of consumption which is sustainable with the environment, the reduction of the ecological footprint, the promotion of information for the consumer to access environmentally sustainable goods, and even the implementation of procedures to prioritise the purchase of sustainable goods in the public area.

Later, in 2018, Ecuador adopted, via the Executive Decree N° 371, the Agenda 2030 for Sustainable Development. Work had however begun in this direction with the approval of the National Development Plan 2017-2021 "Toda Una Vida" ("An Entire Lifetime") (Secretaría Nacional de Planificación y Desarrollo 2018). This national plan is framed in the 17 Aims of Sustainable Development. Aim 12 is oriented to sustainable production and consumption. To this effect, the country must address not only the national production and consumption but take into account the sustainability of its imports. In this area, it is important to highlight that Ecuador has experienced a significant 13.6 points decrease of its external openness rate in the period 2000-2018, due largely to the reduction of the percentage of exports of the GDP and caused by a much higher growth of imports (172.5%) than that of exports (76%).

In 2019, the Decree nº 840 published the First Contribution determined at a national level (NDC) for the Paris Agreement under the United Nations Framework Convention on Climate Change (República de Ecuador 2017). The general aim which is established in this planning is *to implement policies, actions and efforts which foster the reduction of greenhouse gases and the increase of resilience, and the decrease of vulnerability to the adverse effects of climate change in prioritised sectors.* This NDC likewise establishes the aims of reduction of emissions in line with the Paris Agreement, reductions of emissions of between 9 and 20% for the sectors of Energy, Agriculture, Industry and Waste, and between 4 and 20%, for the land sector and the uses of the land.

As is reflected in the NDC, though Ecuador is responsible for a minimum percentage of GHG emissions globally, it is committed to the global fight against climate change. Specifically, 0.12% of the global emissions of 2014 correspond to Ecuador (Banco Mundial 2020), so the interest in their reduction and analysis does not derive from the weight of these emissions in the total count, but its potential growth. Between 2000 and 2014, the increase of Ecuador's total CO_2 emissions was the greatest of the countries of South America -111.98%- while for the rest of the Latin America and the Caribbean (LAC) region the increase was 40.92%, more consistent with the increase of emissions at a world level (46.37%). If we consider the CO_2 emissions per capita during this same period, in the case of Ecuador this growth was 68.52%, a percentage only surpassed by Peru among Latin American countries (79.21%) and much higher than the region's average, as for LAC the emissions per capita grew 19.06% and at a world level 23.36%.

Previous works confirm this evolution in Ecuador's CO_2 emissions during a broader period. Specifically, Román-Collado and Morales (2018) show that despite Ecuador being a country with a low GDPppp growth, it had a high CO_2 emission growth between 1990 and 2013. In fact, the increase of CO_2 emissions is a concern shared by many emerging economies, as previous studies have shown (Muñoz & Steininger 2010). However, this significant growth of CO_2 emissions is a key element that can condition Ecuador's commitments reflected in the NDC.

The aim of this study is to analyse the changes that have taken place in Ecuador in the emissions generated from the production and consumption perspective in the 2000-2015 period based on a Multi-regional Input-Output model (MRIO). This analysis will enable identifying the key production sectors as well as the countries relevant for the generation of Ecuador's Carbon Footprint (CF). The results obtained provide support for decision making in the national planning of environmental policies.

MRIO-based studies allow analysing emissions linked to a country or a region's internal trade from both the consumer's and the producer's perspective. In particular, one of the applications of these models is the calculation of the CF, permitting the calculation of emissions according to the consumption approach (Muñoz & Steininger 2010; Bonilla et al 2015). This type of analysis quantifies direct and indirect emissions (embodied) by product to satisfy a specific final demand. That is to say, the consumption-based approach assigns the responsibility of the emissions to the country or region which acquires specific goods and services which embody emissions (Dolter & Victor 2016).

This means to respond to key research questions, such as: what have been the key explanatory sectors of Ecuador's CO_2 emissions growth in the most recent period, and is Ecuador's production and consumption model sustainable in light of the increase of imports? In the first case, it aims to analyse the evolution of the emissions of the main sectors. These would have a greater margin to centre the measures directed at a long-term strategy and the fulfilling of the objectives foreseen. In the second case, its importance derives from the need to find out the evolution of the consumer's behaviour from the CF point of view to identify if that increase of imports is associated with sustainable consumption and, therefore, clean products or, on the contrary, is based on goods with a greater environmental load.

As far as we are aware, this is the first time a sectoral analysis of the emissions embodied in national production (including exports) but also, the emissions embodied in imports from Ecuador during the period 2000-2015 has been carried out. This analysis allows us to identify the most polluting national sectors and worldwide regions that are involved in Ecuador's national and international trade.

This work is organised as follows. After this introduction, Section 2 presents a review of the scientific literature on the study's topic. Section 3 develops the methodology based on an MRIO approach and describes the data. Section 4 sets out the main results of the model and in Section 5 the results are discussed. Finally, the conclusions and policy recommendations appear in Section 6.

2. Literature review.

The fight against climatic change is a priority for Ecuador, especially due to its being vulnerable to the dramatic effects that this causes, owing to both its equatorial geographical situation and its economic situation (Toulkeridis et al. 2020). Yet, as Jakob (2017) points out, there is a paucity of scientific studies which analyse decarbonisation strategies and the evolution of GHG emissions for lower per capita income countries. This is therefore a matter which it is necessary to go more deeply into (Toulkeridis et al.

2020). The literature has some studies which mainly analyse the evolution of CO_2 emissions, their relation with the GDP trend and the policies of decarbonisation.

Some of these works are centred on the region of Latin America and contribute data for Ecuador, as is the case of the analysis of Robalino-López et al. (2016) and Román-Collado and Morales (2018). Ecuador was classified by Román-Collado and Morales (2018) as a country with a low GDPppp growth and high CO_2 emission growth between 1990 and 2013. Concretely, the CO2 emission growth was due to an important increase in population, but there was also a notably increase in fossil fuels use. In fact, Ecuador is identified as a high carbon intensity country compared with the Latin American average (Robalino-López et al. 2016).

Robalino-López et al. (2014a, 2014b) analyse Ecuador's situation regarding the evolution of its economic growth and emissions, showing the importance of promoting renewable energies and the need for a change of the production model to decouple both variables. Specifically, some research is focused on the analysis of the sustainable electrification of Ecuador in different production sectors. In particular, Carvajal and Li (2019) and Carvajal et al. (2019) show the environmental impact of hydroelectric plants and their possible alternatives; Ramírez et al. (2019) and Martínez et al. (2017) analyse the change in the use of GLP to cook by electricity; and Ramírez et al. (2018) focus on public transport electrification.

On the other hand, the work of Jakob (2017) carries out an analysis of Ecuador's energy policies from the point of view of mitigation. More specifically, there are also works focused on the analysis of specific energy policy measures oriented at the reduction of emissions, such as that of Jacobs et al. (2013) concerning the feed-in tariff instrument, and the study of the fuel subsidies system which Escribano describes (2019), and Martínez et al. (2017) and Schaffitzel et al. (2020) analyse.

There exist some studies for Ecuador about the human footprint, such as those of David et al. (2015) and Tapia-Armijos et al. (2017), which highlight the duality faced by those countries which have a broad ecological diversity but also a strong pressure to increase their economic development levels. This pressure is transmitted concerning their vast natural resources (Escribano 2013). As far as we know no studies about Ecuador's CF have been published.

Nonetheless, Ecuador's international trade relations have been the subject of study, though not directly related with the volume of emissions. As Lapeña and Czubala (2018) show, Ecuador's main trade partners are the USA and China. In recent years, a rapprochement with the latter has taken place, as well as an increase in the presence of Chinese products in Ecuadorian imports, both Chines investments in major Ecuadorian projects and the granting of aids and loans by Chinese financial entities have risen. Yet, as Samanamud (2014) reflects, this relation is very asymmetric due to China being a fundamental pillar of Ecuador's external trade, while Ecuador is just one more partner that the Asian giant uses to increase its production capacity, making use of the former´s natural resources.

Various works analyse international relations and, very especially, the role of China's investments and financial aids, such as those by Escribano (2013), Hogenboom (2014), Casanova et al. (2016), Blanchard (2019) and Lapeña and Czubala (2018). They reflect how these financial aids by the Asian country are not always welcomed by broad sectors of the recipient countries' populations. Herrera-Vinelli (2017) remarks the strong financial dependence that Ecuador has with the Popular Republic of China, its debt in relation with its economy having become large. Notwithstanding, Ecuador considers international aid necessary to advance its development. Specifically, the aims of reducing emissions proposed by Ecuador in the NDC (a 20% reduction) are conditioned by international aid and support (Torres, 2019).

3. Methodology and Database

3.1 Methodology

IO analysis based on the development of Leontief (1936, 1970) is founded on the analysis of Input-Output tables which describe the inter-relations between an economy's distinct sectors. They detail the monetary flows of goods and services between different sectors as well as the final demand (Wilting & Vringer 2010).

Given that IO analysis takes into consideration the links existing between sectors and components of the final demand within a single economy to analyse the relations between various countries and/or regions, it is necessary to use multi-regional input-output (MRIO) analysis. This MRIO approach extends the geographical area and takes into account the relations existing with other economies' demand sectors and components (Gao et al. 2020).

Specifically, and following the naming of the literature (Zhang et al. 2019; Almazán-Gómez et al. 2019), *m* regions are considered within which *n* sectors exist. Hence, the MRIO model has *mxn* linear equations, *R* being the superscript, *S* the regions, *i* being the subscripts, and *j* the sectors:

$$x_i^R = \sum_{S=1}^{m}\sum_{j=1}^{n} x_{ij}^{RS} + \sum_{S=1}^{m} y_i^{RS} \qquad (1)$$

Being x_i^R the total production of the sector *i* in the region *R*, x_{ij}^{RS} the intermediate inputs of the sector *i* in the region *R* which are used by the sector *j* in the region *S,* and y_i^{RS} is the final demand of the sector *i* in the region *R* for region *S.*

Taking into account that $a_{ij}^{RS} = \frac{x_{ij}^{RS}}{x_j^S}$, are technical coefficients which show the requirements of the intermediate inputs of the sector *i* of the region *R* regarding the total production of the sector *j* of region *S*, equation (1) can also be expressed as:

$$x_i^R = \sum_{S=1}^{m}\sum_{j=1}^{n} a_{ij}^{RS} x_j^S + \sum_{S=1}^{m} y_i^{RS} \qquad (2)$$

This equation (2) can be expressed in matrix terms, that is to say:

$$X = A\,X + Y \qquad (3)$$

Operating obtains: $X = (I - A)^{-1}Y$ (4)

Where $L = (I - A)^{-1}$ is the inverse matrix of Leontief of dimension *m**nxn*m*, whose elements, l_{ij}^{RS} are the requirements of production of the sector *i* of region *R* necessary to satisfy one unit of final consumption of the sector *j* of the region *S*.

If we multiply both members of equation (4) by e, the diagonal matrix of emissions coefficients, whose elements, $e_i^R = \frac{e_i^R}{x_i^R}$ represent the emissions generated per unit of production of the sector *i* in the region *R*, one obtains the matrix E:

$$E = e \cdot L \cdot Y \tag{5}$$

Specifically, the sum of the elements of the matrix E by columns permits obtaining the CF and by rows the emissions from the EPP. Therefore, from equation (5), one can obtain the CF and the EPP of a specific region *S*, in general or by sectors:

$$CF^S = \sum_{R=1}^{m} \left(\sum_{j=1}^{n} \sum_{i=1}^{n} E_{ij}^{RS} \right) \tag{6}$$

$$EPP^S = \sum_{S=1}^{m} \left(\sum_{j=1}^{n} \sum_{i=1}^{n} E_{ij}^{RS} \right) \tag{7}$$

The following components are defined for the interpretation of the analysis of the CF from the point of view of the sectors:

Direct Domestic Emissions: those CO_2 emissions embodied in the products and services generated by and for the same reference sector, generated in a specific country: $EDD_i^S = E_{ij}^{RS}$, for which $i = j$ y $R = S$ (8)

Indirect Domestic Emissions: those CO_2 emissions embodied in the products and services generated by other sectors within the country and consumed by the sector analysed. The sum of the direct and indirect domestic emissions is the domestic CF.

$$EID_i^S = \sum_{i=1}^{n} E_{ij}^{RS} \text{ , whenever } R = S \text{ and for all } i \neq j \tag{9}$$

External Indirect Emissions: those emissions embodied in the sector's imports. These emissions are the CF, without including what is domestic.

$$EIE_j^S = \sum_{R=1}^{m} \left(\sum_{i=1}^{n} E_{ij}^{RS} \right) \text{ , whenever } R \neq S \tag{10}$$

At this point it is desirable to establish that the global emissions do not change according to the approach used, “consumption-based” or “production-based”, as only the way in which these emissions are assigned to each country changes (Wilting & Vringer 2010; Dolter & Victor 2016).

On the other hand, for a specific country or region, the Emissions Trade Balance (ETB) can be determined, showing the difference between the emissions embodied in the exported national production minus the emissions embodied in the imports of goods and services for national consumption. This would be given by the following equation:

$$ETB^S = EPP^S - CF^S \qquad (11)$$

Finally, considering the definition of Román et al. (2016), the total emissions embodied in the international trade (EEIT) of a specific country or region *S* can be analysed as the difference between the emissions embodied in the exports (EEE) and the imports (EEI):

$$EEIT = EEE^S + EEI^S = \sum_{R=1}^{m}\left(\sum_{j=1}^{n}\sum_{i=1}^{n} E_{ij}^{RS}\right) + \sum_{S=1}^{m}\left(\sum_{j=1}^{n}\sum_{i=1}^{n} E_{ij}^{RS}\right), whenever\ R \neq S \qquad (12)$$

EEIT, enables determining the global emissions generated as a consequence of the international trade (including exports and imports) of a certain country or region. The environmental pressure that this country or region has at the global level is obtained, measured in terms of emissions.

3.2 Database

Monetary tables (based on a mix of basic-price and purchaser-price data) and the satellite accounts from EORA have been used. Gross information of the United Nations System of National Accounts and the databases of COMTRADE, Eurostat, IDE / JETRO and various national agencies was obtained for the generation of the base (Lenzen et al. 2012; 2013).

The harmonised classification that the simplified version (Eora26) has defined with 26 sectors (See Table A1) and 187 countries/regions (See Table A2) has been used for the calculations. As a consequence of the aggregation of sectors, differences can arise between the complete and simplified EORA bases. However, this effect is less pronounced for the level that is being considered in this study (Steen-Olsen et al., 2014; 2016).

For the presentation of the results the information for 6 regions has been aggregated (See Table A2): ECU (Ecuador), BRICS (Brazil, Russia, India, China and South Africa), LAC (Latin America and the Caribbean), NA (North America), EU (the European Union), RoW (Rest of the World) and 8 sectors (See Table 1): primary, secondary, electricity, gas and water, construction, hotels and trade, transport, other services and re-exportation and re-importation. The regions have been defined according to Ecuador's main trade partners in 2015, taking into account that this type of consideration is frequent in the literature (Tukker et al. 2016; Dolter & Victor 2016; Wilting & Vringer 2010). The 8-sector scale classification has been based on the studies of Dolter and Victor (2016), Minx et al. (2010), and Turner et al. (2008), establishing the necessary specifications according to Ecuador's particularities.

The present study centres its analysis on three years: 2000, 2008 and 2015. The year 2000 is a reference of the new millennium, when Ecuador adopted the dollar currency. This followed one of the greatest crises that the country has had to face and whose origin was the financial sector, underlining the impact in 1999. The year 2008 is an intermediate reference, defining the situation and starting point of the constitutional change, considering all the economic, social and especially environmental implications which this entailed. Finally, the analysis for the year 2015 is determined as a post-constitutional change, being the last reference year for the country available in the database.

For the reference years, the information of CO_2 emissions for the environmental extension of the MRIO was taken from the satellite accounts of EORA and, failing this, from the EDGAR (Emission Database for Global Atmospheric Research) database version 4.3.2. (Olivier et al. 2016).

4. Results.

The analysis of results has allowed us to present the evolution of the four magnitudes; that is, the Carbon footprint (CF), the Emissions based on the Production Principle (EPP), the Emissions Trade Balance (ETB) and the Emissions Embodied in International Trade

(EEIT), both at the national level and in the country's relation with the regions considered, and at the sectoral level, considering also the links with the distinct regions. The general results are presented in Table B1 (Annex B).

4.1 National Level Analysis

The results concerning the volume of emissions of Ecuador according to the two perspectives (consumer and producer), in the three years of analysis, are shown in Table 1.

The CF of the country, that is to say the CO_2 emissions under the ECP, went from 18554.02 Gg in 2000 to 31814.24 Gg in 2008 (71.47%) and to 45506.01 Gg in 2015 (43.04% with respect to 2008), resulting in a growth of 145.26% compared to 2000.

On the other hand, the emissions under the EPP had a lower growth. In 2000 they were 19498.95 Gg, had grown by 58.38% in 2008 (30882.86 Gg) and for the year 2015 had risen by 35.19% with respect to 2008 (a growth of 114.11% between 2000 and 2015), reaching 41749.09 Gg.

Table 1: Ecuador's CO_2 emissions by destination and origin

	Gigagrams			Variation (%)		
	2000	**2008**	**2015**	**2000-2008**	**2008-2015**	**2000-2015**
Carbon Footprint: (1)+(2)	18554.02	31814.24	45506.01	71.47%	43.04%	145.26%
ECU: domestic emissions (1)	14039.93	22721.32	33322.58	61.83%	46.66%	137.34%
Emissions of Imports (2)*[1]	4514.09	9092.92	12183.43	101.43%	33.99%	169.90%
LAC (3)	1126.29	2414.86	3356.06	114.41%	38.98%	197.98%
NA (4)	1407.59	2401.97	3145.64	70.64%	30.96%	123.48%
EU (5)	528.97	899.33	1083.43	70.02%	20.47%	104.82%
BRICS (6)	700.39	2159.47	2975.79	208.33%	37.80%	324.88%
RoW (7)	750.86	1217.28	1622.52	62.12%	33.29%	116.09%
Emisiones CO_2 EPP	19498.95	30882.86	41749.09	58.38%	35.19%	114.11%
ECU: domestic emissions	14039.93	22721.32	33322.58	61.83%	46.66%	137.34%
Emissions of Exports (8)	5459.02	8161.54	8426.51	49.51%	3.25%	54.36%
LAC	1629.07	2563.25	3146.58	57.34%	22.76%	93.15%
NA	1676.28	2293.92	2021.90	36.85%	-11.86%	20.62%
EU	826.66	1303.64	1098.19	57.70%	-15.76%	32.85%
BRICS	291.21	622.98	727.12	113.93%	16.71%	149.69%
RoW	1035.80	1377.76	1432.72	33.01%	3.99%	38.32%

ETB = (8) – (2)	944.93	-931.37	-3756.92	-198.57%	303.37%	-497.59%
EEIT= (8) + (2)	9973.11	17254.46	20609.93	73.01%	19.45%	106.66%

Source: Own elaboration.

*[1](2) = (3)+(4)+(5)+(6)+(7)

Notwithstanding, the behaviour of the emissions under the consumption and production principal has not been the same in the three years considered. In 2000, Ecuador's CF was almost 5% less than the CO_2 under the EPP, while for 2008 and 2015 the relation is reversed, the CF being greater than the EPP emissions by 3% and 9%, respectively, for those years. Specifically, the emissions embodied in the imports went from 4514.09 Gg in 2000 to 12183.43 Gg in 2015 (a growth of 169.90%), while the emissions embodied in exports increased from 5459.02 Gg to 8426.51 Gg (an increase of 54.36%). Thus, Ecuador's ETB went from 944.93 Gg in 2000 to a value of -3756.92 Gg in 2015.

The difference between the CF and the EPP can be mainly explained by two factors: a change in the trade balance of goods, and the distinct intensity of emissions of imported and exported goods (Wilting & Vringer 2010).

In the period analysed, the increase of the emissions due to imports (169.90%) has grown three times more than those as a result of exports (54.63%). In particular, Ecuador's current account balance began to be negative from 2007-2008, specifically by 1366.5 million dollars (Banco Mundial 2020). Therefore, the greater volume of imports is one explanatory factor of why the CF is higher than the EPP from this year. However, the accelerated growth of the CO_2 emissions embodied in imports has been abruptly greater than that expressed in monetary terms, giving a relation of 3 to 1 for the 2008-2015 period (a growth of imports in monetary terms of 11.25%, compared to a growth of imports in terms of emissions of approximately 34%) (Banco Mundial 2020).

As to the local CO_2 emissions derived from the consumption of national production (domestic emissions), they rose from 14039.93 Gg (2000) to 22721.32 Gg (2008) and to 33322.58 Gg (2015), growing 137.34% between 2000 and 2015. These domestic emissions are more than 70% of the CF and of the EPP approach of Ecuador during all the period analysed.

Finally, having analysed the emissions due to imports and exports as a whole, that is to say the EEIT, Ecuador's participation in world trade means that its world environmental pressure has gone from representing 9973.11 Gg in 2000 to 20609.93 Gg in 2015. This is an increase of 106.66%.

4.2 Analysis of the link between Ecuador and the Regions

The data relative to the CF show that in 2000 the region which most affected the volume of emissions embodied in the imports of Ecuador was North America (NA) with 1407.59 Gg (7.56% of the total). However, in 2008, Latin America and the Caribbean (LAC) was the most important region with 2414.86 Gg (7.59% of the total), maintaining its position in 2015 with 3356.06 Gg (7.37% of the total). Likewise, it is important to underscore the growing importance of the carbon emissions embodied in the imports from the BRICS nations (324.88% de 2000 a 2015), which represent 24 % of the total CO_2 emissions for 2015.

When we analyse the data relative to the EPP in 2000, the regions which had more weight in the volume of emissions embodied in Ecuador's exports are NA and LAC. This situation is reversed in 2008 and 2015, LAC being the region of origin with a greater volume of emissions embodied in the exports (3146.58 Gg), far above NA (2021.90 Gg) and the BRICS countries (1432.72 Gg). In the same way, the volume of emissions embodied in Ecuador's exports significantly increase in the BRICS for the period analysed (150% approximately).

Figures 1 and 2 show the relative weight of each of the regions as importers (destination) or exporters (origin) of emissions embodied towards and from Ecuador.

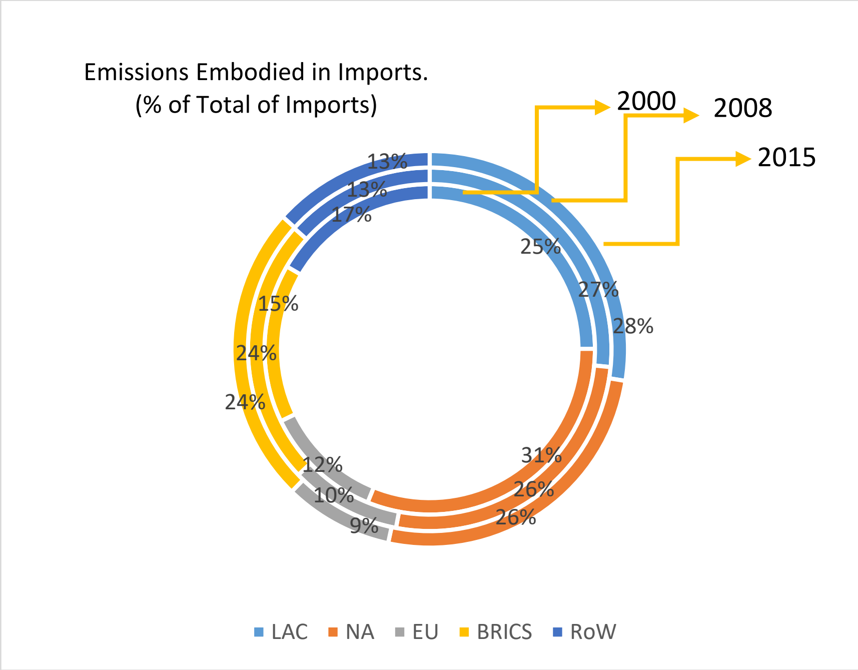


Figure 1: Emissions Embodied in Imports of Ecuador for Region of Origin (% of Total of Imports).

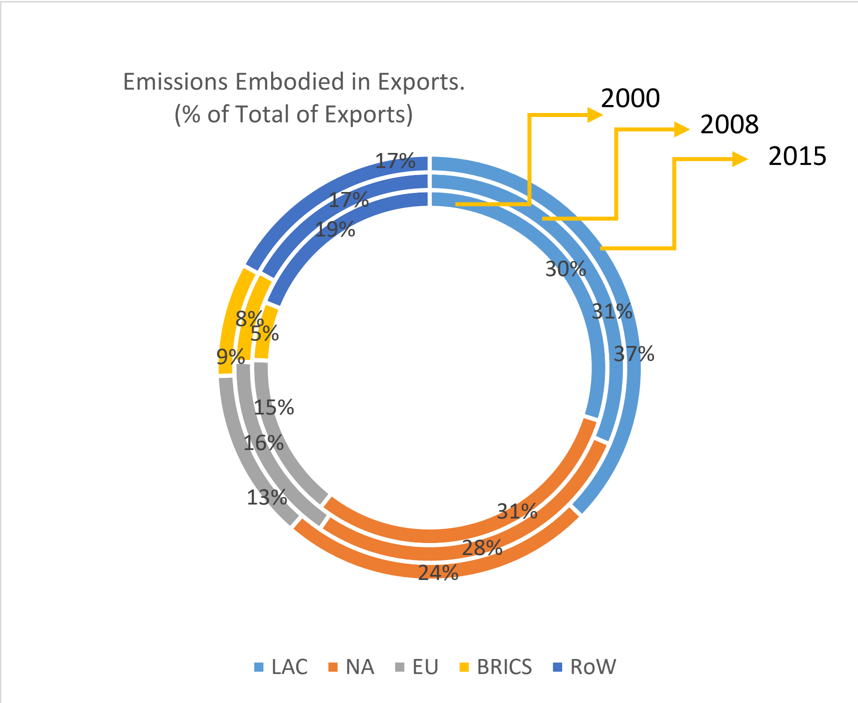


Figure 2: Emissions Embodied in Exports of Ecuador for Region of Origin (% of Total of Exports)

We highlight the increase of the participation of the BRICS nations as to the origin region of the emissions embodied in Ecuador's imports, reaching a weight of 24% of the 2015 total. On the contrary, its weight as a destination region of the emissions embodied in Ecuador's exports has been maintained at minimum levels. This would in part explain the growing gap between the CF and the emissions calculated under the EPP for this zone. Another interesting aspect is the growth in the weight which the LAC region has as the destination of the emissions embodied in Ecuador's exports, which goes from 30% to 37%.

On the other hand, Figure 3 shows the weight emissions embodied in Ecuador's imports and the exports with each region, according to the reference year. Regarding the BRICS countries, Ecuador has been a net importer in the three years considered. As to regions such as LAC and the Rest of the World (RoW), Ecuador has gone from being a net exporter in 2000 and 2008 to being a net importer in 2015. Ecuador has reversed the previous trend with NA, going from being a net exporter in 2000 to a net importer in 2008 and 2015. In 2015, Ecuador was a net importer of emissions embodied from all the regions considered, except the case of the European Union (EU). For the latter, Ecuador has continued being a net exporter of emissions, although the gap is increasingly smaller.

Figure 3: Exchange of Emissions between Ecuador and the different Regions

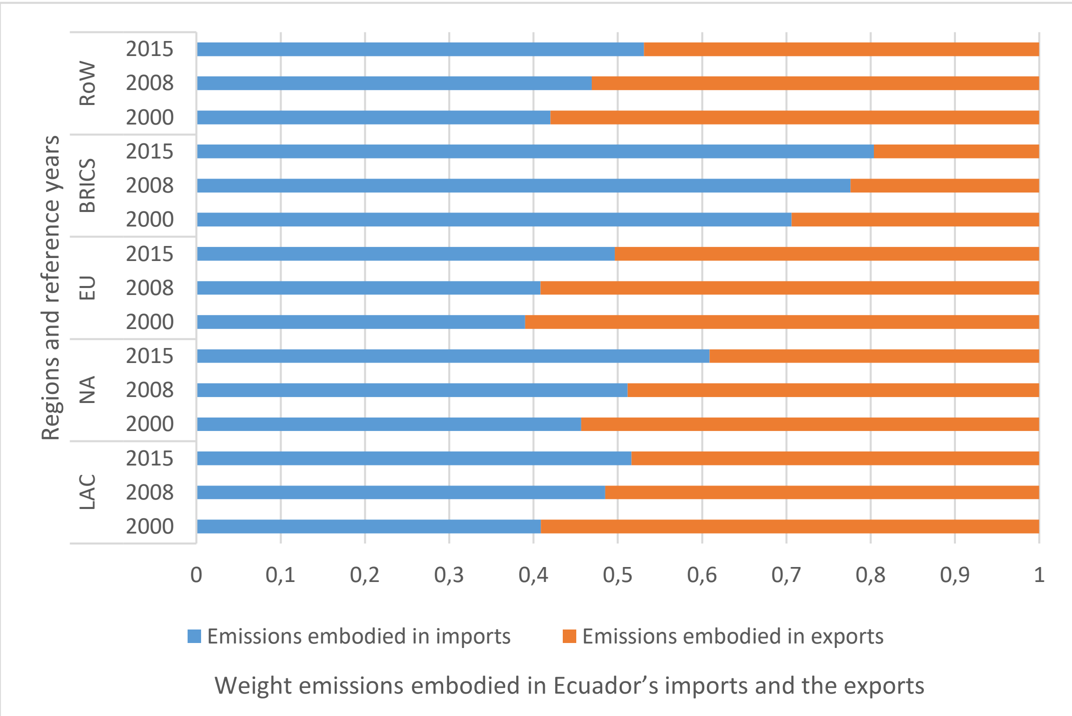


Figure 4 shows the total environmental pressure generated by Ecuador's international trade with the distinct regions considered, according to the years of reference and distinguishing between those due to exports and to imports. The results show that LAC, BRICS, NA and the RoW have been gaining weight in Ecuador's EEIT between 2000 and 2015, especially due to imports. In the case of the EU, the volume of EEIT has been maintained since 2008, those due to imports increasing. In particular, it is to be emphasised that, from 2008, LAC has been the region with which the trade relations have generated a greater environmental stress. This is without ignoring NA's considerable participation and the abrupt change that has taken place with the BRICS nations.

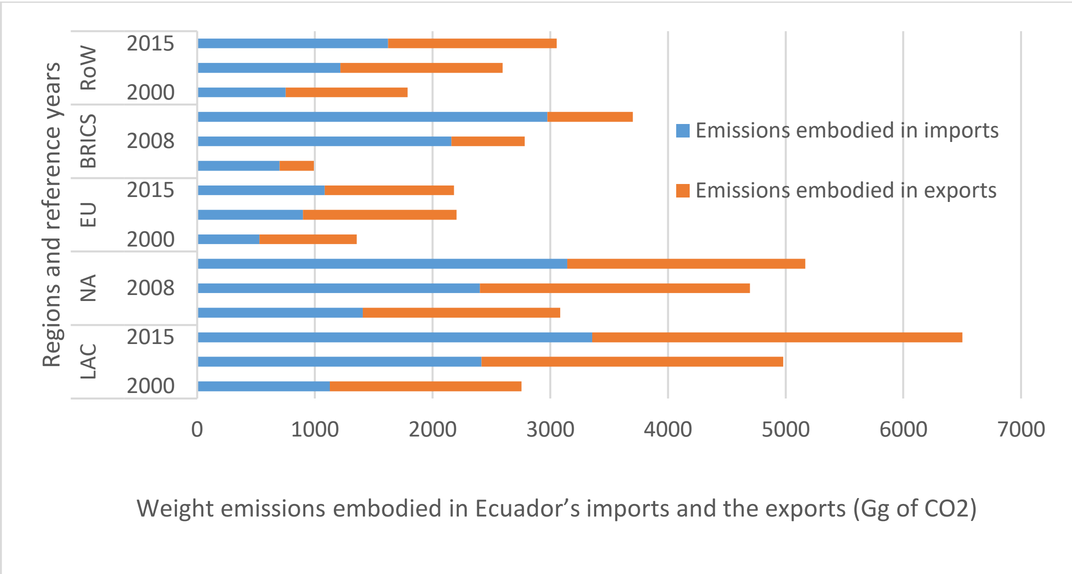


Figure 4: Total Emissions Included in Ecuador's Trade with the distinct Regions

4.3 Sectoral analysis of emissions trade in Ecuador.

Table 2 presents the results for each of the variables considered; that is, CF, EPP and ETB corresponding to Ecuador, detailed for each of the sectors and years considered in the analysis.

Table 2: Ecuador's CO_2 emissions by Sectors (CF, EPP, ETB)

Sectors	CF			EPP			ETB		
	2000	2008	2015	2000	2008	2015	2000	2008	2015
Primary Sector	714.72	1090.80	1600.68	2773.96	4043.11	5606.87	2059.23	2952.31	4006.19
Secondary Sector	5945.54	9953.02	14252.44	4090.63	5529.21	8034.65	-1854.91	-4423.81	-6217.79
Electricity, Gas and Water	1114.51	2173.93	3215.46	2429.60	5335.80	6838.70	1315.09	3161.87	3623.24
Construction	1642.73	2742.35	3620.43	360.28	573.49	770.64	-1282.45	-2168.86	-2849.79
Hotels and Trade	260.10	478.09	651.50	88.98	167.12	310.95	-171.12	-310.97	-340.54
Transport	7736.99	12486.72	18140.68	9595.30	14684.00	18990.00	1858.31	2197.28	849.32
Other Services	1101.68	2817.96	3920.01	160.20	550.14	1197.28	-941.48	-2267.82	-2722.73
Re-export & Re-import	37.75	71.37	104.82	0.00	0.00	0.00	-37.75	-71.37	-104.82
TOTAL	18554.02	31814.24	45506.01	19498.95	30882.86	41749.09	944.93	-931.37	-3756.92

From the CF point of view, the transport sector and the secondary sector are those which are generators of a greater volume of CO_2 emissions: 18140.68 Gg (40% of the total) and 14252.44 Gg (31% of the total), respectively, in the year 2015. In the period analysed, an increase of its footprint of more than double has occurred in all the sectors. This increase has been especially marked in the sectors of Other services, of Electricity and of Trade which, setting out from relatively moderate emissions levels, have experienced growth rates between 2008 and 2015 of 255.8%, 188.5% and 150.5%, respectively.

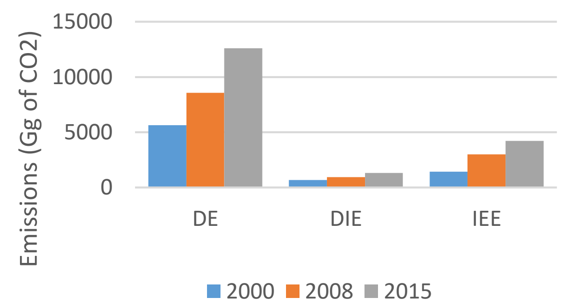
On the other hand, from the EPP perspective we identify the transport sector as the most pollutant during all the period of analysis, followed by the secondary sector. In turn, the primary and electricity, gas and water sectors stand out for their remarkable participation in the emissions of 2015, attaining a volume of 5606.87 Gg and 6838.7 Gg, respectively.

From the ETB perspective it is noted that the secondary sector, that of construction, that of trade and that of other services are net importers of emissions compared to the primary, electricity, gas, water and transport sectors which are net exporters of emissions in all the period considered. This shows the important dependence of these sectors on imports.

To go deeply into the behaviour of the emissions of the sectors according to their origin, Figure 5 shows Ecuador's CF in the last three years analysed, broken down into the direct emissions and domestic indirect as well as the indirect imports. The direct (DE) and domestic indirect emissions (DIE) show the weight of the emissions of the sectors caused by the consumption of national production, either generated by the sector itself or by other national sectors. For their part, the imported indirect emissions (IEE) are the emissions caused by a specific sector's import need.

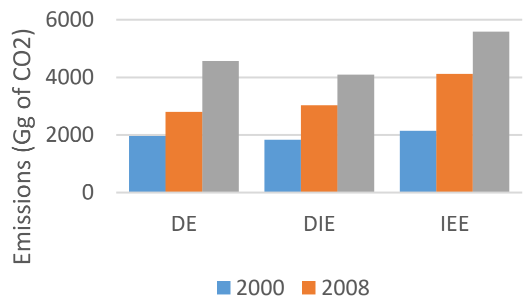
As shown in Figure 5a, more than 70% of the emissions generated by the transport sector are direct; that is to say, they are emissions embodied in the products and services generated by and for the transport in the country itself. Nevertheless, the growth experienced by the imported indirect emissions (197%) between 2000 and 2015 stands out. Also, the electricity sector's CF is mainly due to the direct emissions (90%) those that are indirect being marginal (Figure 5e).

Figure 5.a



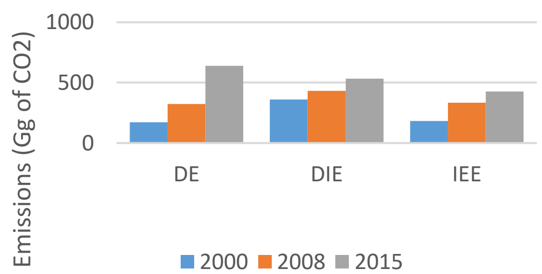
Carbon Footprint of Ecuador. Transport sector

Figure 5.b



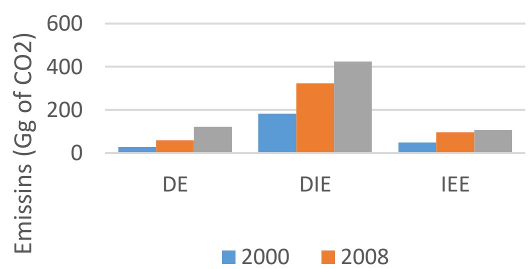
Carbon Footprint of Ecuador. Secondary sector

Figure 5.c



Carbon Footprint of Ecuador. Primary sector

Figure 5.d



Carbon Footprint of Ecuador. Hotels and Trade sector

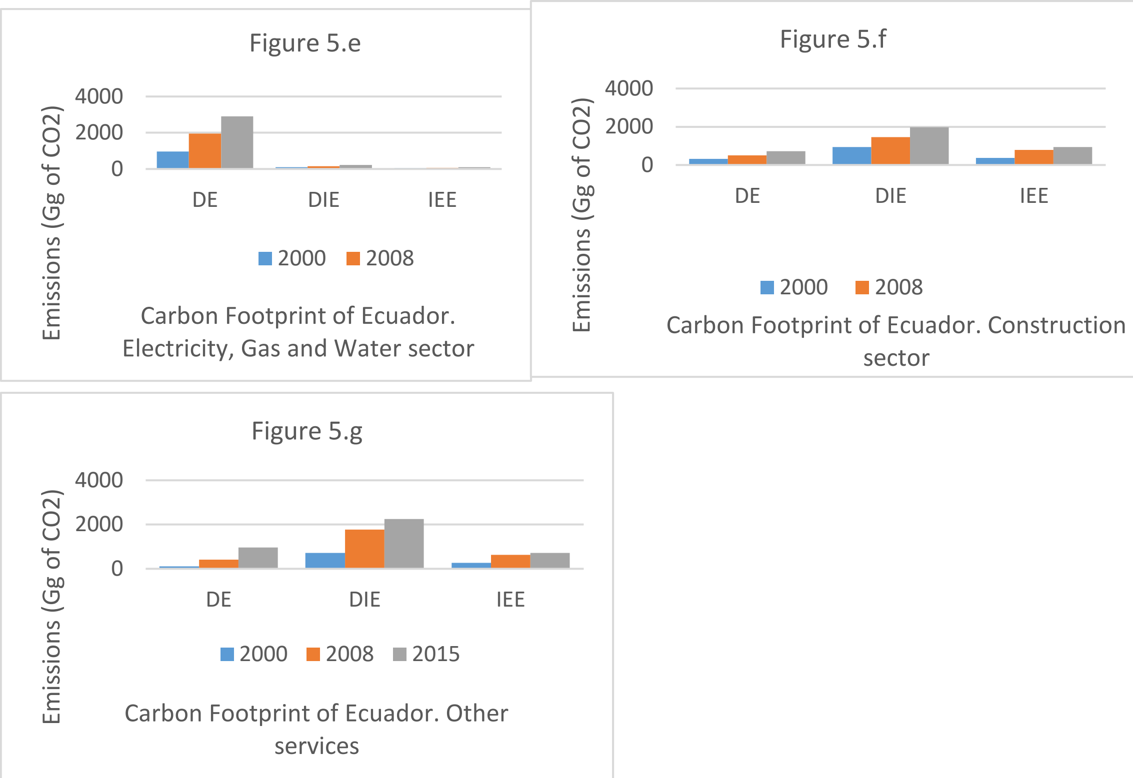


Figure 5: Carbon footprint of Ecuador by sectors and reference years (Gg of CO2).

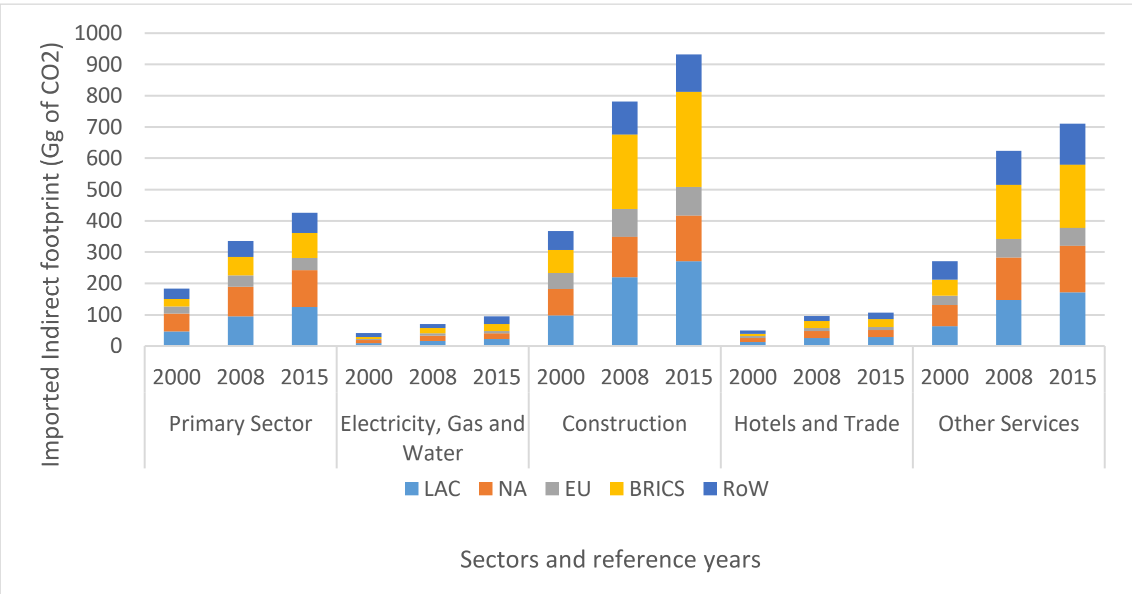
Figure 5b shows the secondary sector, one of the most pollutant in Ecuador. The CF is fairly distributed among the three types: direct, domestic indirect and imported indirect emissions although the latter should be highlighted due to its having shown an important increase (160%) between 2000 and 2015. This behaviour has also been reported in the case of the primary sector as can be seen in Figure 5c, where the imported indirect emissions increased by 132% between 2000 and 2015 (see Table B2).

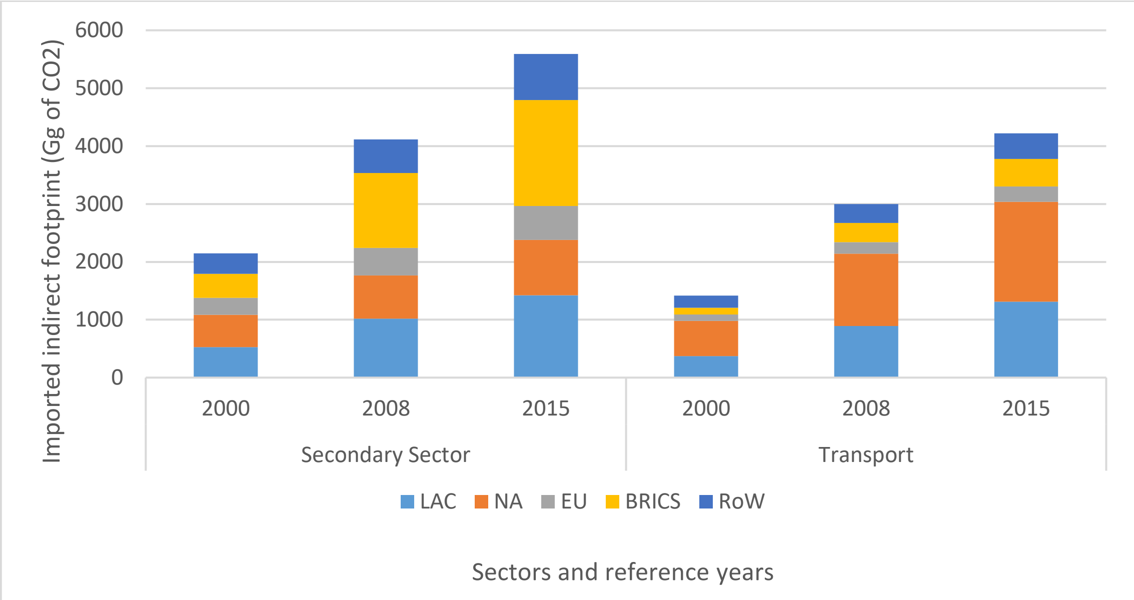
As to the sectors in which Ecuador's footprint has grown most, similarities are seen between "Other services" and "Hotels and Trade", in which more than half the CF is generated by domestic indirect emissions. That is to say, that they are emissions embodied in the products and services generated by other sectors within Ecuador, but they are consumed in the two sectors, respectively. This pattern is also seen in the case of the construction sector, though here we must emphasise the significant growth of the imported indirect emissions (154%) between 2000 and 2015 (Figure 5f).

Figures 6a and 6b represent the breakdown by geographic zones of the imported indirect footprint (see the detail in Table B3 of the Annex). In this case, the behaviour of the two sectors with the greatest footprint has been different. For 2015, the analysis of the imported indirect emissions for the transport sector shows that 40% come from the NA and 31% from LAC. Since in 2000 LAC only represented 26% of imported indirect emissions of the transport sector, these new percentages show the importance that the LAC region is gaining in Ecuador's international trade.

In 2015, in the case of the secondary sector, the origin of the imported indirect emissions is as follows: 35% from the emerging countries region (BRICS), 25% from LAC and 17% from NA. If these percentages are compared with those of 2000, some differences arise due to the importance that the BRICS region is attaining in the imported indirect emissions of this sector, parallel to a diminishing in the relative weight of the NA region. These results can be analysed from the perspective of this sector's CF, being the most pollutant of all the sectors. As has been highlighted previously, the indirect imported emissions of this sector have increased by 160% between 2000 and 2015 and represent almost 40% of the total CF. This is why the changes in the relative weight that the regions have in these emissions have to be analysed in detail.

The NA, LAC and BRICS regions are those which have a greater weight in Ecuador's imported indirect emissions, both in the two sectors mentioned and in that of Construction and that of Other services, as can be seen in Figures 6a and 6b.





Figures 6a and 6b: Imported indirect footprint by sectors and reference years.

5. Discussion

The analysis of CO_2 emissions for Ecuador shows an accelerated growth from both the producer's and the consumer's perspective, increasing 145.3% and 114.1%, respectively, between 2000 and 2015. This major growth of emissions embodied in consumption is due to the strong growth experienced in the 2000-2008 expansion stage (71%), much more tempered in the 2008-2015 period (43%).

On the other hand, accounting for emissions from the consumer's and producer's point of view shows that the domestic CO_2 emissions represented 76% and 72%, respectively, of the total emissions calculated in 2000, and were 73% and 80%, respectively, in 2015. This data implies that the greatest efforts that Ecuador must make to move towards a low carbon economy has to be centred on local production and national consumption.

Given the important relative weight of domestic emissions in the total calculation of Ecuador's emissions, both calculated according to the CF or EPP approach, the particular study of those sectors responsible for these emissions is required. The analysis of the sectors which have a greater relative weight in Ecuador's domestic emissions throughout the period analysed shows that these are the secondary and transport sectors, representing 26% and 42%, respectively, in 2008 and 2015. The two sectors explain more than 60% of the domestic emissions. In turn, the increase of the relative importance of the sector Other services in the domestic emissions total should be stressed. This went from representing 6% in 2000, to 10% in 2008 and 2015.

On the other hand, it is seen that the CF is higher than the emissions calculated under the EPP in the years 2008 and 2015, Ecuador becoming a net emissions importer country. The growing gap in the ETB is due not only to Ecuador's trade deficit since 2008, but also to the influence of aspects related with the change of its trade patterns, such as the increase of trade relations with the BRICS region. This trend is consolidated for China, as Samanamud (2014) reflects, pinpointing the growth between 2001 and 2011 of the trade relations between the two countries. Lapeña and Czubala (2018) are in line with this when they study the trade relations between the two countries for 2016.

This fact coincides with the results attained by Peters et al. (2011), who show that the CO_2 emissions embodied in trade with countries which are not part of Annex B of the Kyoto Protocol have had a quick growth (21.5% from 1900 to 2008). On the other hand, numerous authors, such as Davis and Caldeira (2010), Deng and Xu (2017) and Tukker et al. (2016) have identified China, Russia, South Africa and India among the countries which are the main net exporters of CO_2 to the world.

At the sectoral level, it is noted that the secondary and transport sectors represent approximately more than 30% and 40%, respectively, of Ecuador's CF in the period analysed. Nonetheless, the emissions embodied in the exports only explain 46% and 35% in 2015. The two sectors justify more than 80% of these emissions and are determinants of their evolution in the 2000-2015 period. Specifically, in the case of the secondary sector it is worth highlighting the significant relative weight which this represents (62%) of the emissions embodied in the imports from the BRICS countries in 2015. This percentage has increased in the period studied, being 59% in 2000. In turn, in 2015, the transport sector is responsible for 55% and 39% of the emissions embodied in the imports from NA and LAC, respectively. This percentage has increased considerably in the period studied, as in 2000 it was around 43% and 33%, respectively.

In the international area, considering both the emissions embodied in Ecuador's imports and in its exports, this country generated 20609.93 Gg of CO_2 emissions in 2015. A substantial increase took place between 2000 and 2015, due mainly to the increase of imports, and within these to the rise of almost 200% of those from LAC and more than 300% of the imports from the BRICS. The significant weight of the secondary and transport sectors in Ecuador's domestic emissions place these two sectors in Ecuador's spotlight, as do the emissions embodied in its imports, especially from emerging countries (BRICS), from NA and LAC, whose emissions have increased most in the period analysed.

In relation with the transport sector, there are various studies which identify its importance for Ecuador's emissions and propose improvements. In particular, Buenaño (2017) recognizes it as one of the most influential in Ecuador's generation of CO_2 in 2013. In the same line, Guayanlema (2013) estimates that around 85 to 90% of emissions come from land transport (5-6% from sea transport and an average of 3.8% from air transport), and likewise indicates that extra petrol is the fuel most used for light transport, followed by diesel, for heavy load transport. One of the key elements to favour Ecuador's decarbonisation is the elimination or reduction of petrol and diesel subsidies with the aim of fostering other, alternative energy sources, though as Escribano (2019) and Schaffitzel et al. (2020) note, this is a very complex topic and one which is greatly rejected in Ecuadorian society. A proof of this is the derogation two weeks after its publication of the Executive Decree 883, which eliminated the subsidies of normal petrol and diesel.

Another action line, as Ramírez et al. (2018) point out, is electrification to mitigate these emissions. There are diverse programs promoted by the Ecuadorian government and aimed at the decarbonisation of transport. The Vehicle Renovation Plan – RENOVA - the National Plan for Bike Paths, and projects such as the Quito Metro and the Cuenca Tram (MAE 2017) stand out. In particular, the RENOVA Plan means to renovate the public transport car pool through the scrapping of units which have served their useful life, granting an economic incentive for purchasing new national production vehicles at a preferential price and via the waiving of customs tariffs for those that are imported (MTOP 2015). This plan was supplemented with new public transport renovation plans in Ecuador, such as the Plan Renova 2.0 (MTOP 2017). However, Guayanlema (2013) estimates that were the Plan RENOVA maintained until 2040, it would mean a reduction of not more than 3.11% of the emissions due to its being aimed uniquely at public transport, which only represents 5.43% of the total fuel consumption.

On the other hand, and as Jakob (2017) points out, as well as continuing with the initiatives of renovation of the vehicle pool (Quinde 2017), this should be supplemented with the promotion of electric vehicles and bike paths. There ought also to be an increase of public transport, the establishing of a carbon tax for public and private transport, and the promotion of environmental research and education.

Ecuador's government has as well adopted different initiatives with a view to reducing its emissions in the secondary sector, such as is the case of the project of Pollutant Release and Transfer Register (RETC) (MAE 2014b), with a validity period of 2010 to 2015, and whose aim has been to identify and account for pollutants, especially in the industrial sector. This project has continued in successive editions until now. Other initiatives have been the certification system -"Green Point"- for those producers which meet specific standards and carry out good environmental practices, and the creation in 2013 of the Ecuadorian Centre of Efficiency of Resources and Cleaner Production (CEER), in charge of diagnosing the production of firms (MAE 2017).

Additionally, other climate change mitigation measures adopted are mainly the Ministerial Agreement N° 264 of 2014 (MAE 2014a) and the Ministerial Agreement N° 140 of 2015 (MAE 2015). The former accords the Environmental Ecuadorian Recognition "Neutral Carbon", with the aim of reducing and offsetting GHG emissions by public and private natural and legal persons. The latter are integrated general environmental indicators, the calculation of the organisational ecological foot print, and economic incentives such as tax deductions and credits with environmental considerations are included.

6. **Conclusions.**

Ecuador's Carbon Footprint has had a massive growth of 145.26% between 2000 and 2015, showing an increase even greater than that of the emissions calculated according to the EPP (114.11%), the country becoming a net importer of embodied emissions after having been a net exporter in 2000. Ecuador's growth of economic activity, its trade balance deficit (since 2008) and new consumption patterns explain this situation.

The significant volume of domestic and imported emissions identify the secondary and transport sectors as keys to reduce Ecuador's emissions. The transition to an economy low in emissions shows the need to reduce the emissions embodied in the production not only of these sectors but of the rest of the sectors linked to them (indirect domestic emissions). Efforts must be especially concentrated on the primary sector and on Electricity, Gas and Water, as each of them constitutes 39% of those domestic indirect emissions. These emissions for the electricity sector have almost tripled in the study period, albeit the growth has slowed down in the second sub-period, having gone from a variation rate of 129% between 2000 and 2008 to 25% between 2008 and 2015. This supports the idea that the measures launched in the electricity sector in recent years are producing moderate results.

On the other hand, the importance of fostering a responsible and sustainable consumption compels reducing the emissions embodied in consumption; that is to say, the emissions identified in the CF. To do so, it is necessary to work on the domestic emissions, but this especially involves reducing the emissions embodied in the imports which have substantially increased in the period analysed. In this case, a significant increase of the emissions coming from the BRICS countries has been seen, as well as from the LAC region. In both cases the growths are greater in the first part of the period. This change has caused the deficit of the emissions balance and Ecuador's greater external dependence.

This calculation of the Ecuador's CF during the years 2000-2015 therefore strengthens the need to foster a change in the population's and the public administrations' consumption patterns. So it is recommended that the authorities, on the basis of these rigorously obtained results, allocate part of the public budget to measures oriented to sustainable consumption. These measures could be the extending of the RENOVA Plan to private vehicles and strong awareness campaigns about the degree of sustainability of imported products. This type of measures could slow down the strong growth of emissions per capita, indispensable to reduce the country's CF.

Ethics approval and consent to participate.

Not applicable

Consent for publication.

Not applicable

Data availability.

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interest.

The authors declare that they have no competing interests.

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Authors' contributions

RC (Román-Collado), SD (Sanz-Díaz) and L (Loja) contributed to the study conception, design, material preparation, data collection and analysis. RC was in charge of the supervision and funding acquisition.

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ANNEX A

Table A1: Original classification of sectors contained in Eora26 and aggregation for the analysis of the study.

<table>
<tr><th colspan="2">Sectoral Classification in Eora26:</th><th colspan="2">Aggregation</th></tr>
<tr><td>1</td><td>Agriculture</td><td rowspan="3">1</td><td rowspan="3">Primary Sector</td></tr>
<tr><td>2</td><td>Fishing</td></tr>
<tr><td>3</td><td>Mines and quarries</td></tr>
<tr><td>4</td><td>Food and beverages</td><td rowspan="9">2</td><td rowspan="9">Secondary Sector</td></tr>
<tr><td>5</td><td>Textiles and clothing</td></tr>
<tr><td>6</td><td>Wood and paper</td></tr>
<tr><td>7</td><td>Petroleum, chemical and non-metallic mineral products</td></tr>
<tr><td>8</td><td>Metallic products</td></tr>
<tr><td>9</td><td>Electrical and machinery</td></tr>
<tr><td>10</td><td>Transport Equipment</td></tr>
<tr><td>11</td><td>Other industrial sectors</td></tr>
<tr><td>12</td><td>Recycling</td></tr>
<tr><td>13</td><td>Electricity, gas and water</td><td>3</td><td>Electricity, Gas and Water</td></tr>
<tr><td>14</td><td>Construction</td><td>4</td><td>Construction</td></tr>
<tr><td>15</td><td>Maintenance and repair</td><td rowspan="4">5</td><td rowspan="4">Hotels and trade</td></tr>
<tr><td>16</td><td>Wholesale trade</td></tr>
<tr><td>17</td><td>Retail trade</td></tr>
<tr><td>18</td><td>Hotels and restaurants</td></tr>
<tr><td>19</td><td>Transport</td><td>6</td><td>Transport</td></tr>
<tr><td>20</td><td>Post and telecommunications</td><td rowspan="6">7</td><td rowspan="6">Other Services</td></tr>
<tr><td>21</td><td>Financial intermediation and commercial activities</td></tr>
<tr><td>22</td><td>Public administration</td></tr>
<tr><td>23</td><td>Education, health and other services</td></tr>
<tr><td>24</td><td>Private homes</td></tr>
<tr><td>25</td><td>Others</td></tr>
<tr><td>26</td><td>Re-exports and re-imports</td><td>8</td><td>Re-exports and re-imports</td></tr>
</table>

Table A2: Original classification of Eora26 countries by analysis regions.

Region: BRICS

Eora26 Numbering	Country
26	Brazil
40	China
79	India
142	Russia
156	South Africa

Region: North America (NA)

Eora26 Numbering	Country
34	Canada
70	Greenland
181	USA

Region: Ecuador (ECU)

Eora26 Numbering	Country
54	Ecuador

Region: European Union (EUE)

Eora26 Numbering	Country	Eora26 Numbering	Country	Eora26 Numbering	Country
11	Austria	**69**	Greece	**136**	Poland
18	Belgium	**77**	Hungary	**137**	Portugal
29	Bulgaria	**83**	Ireland	**141**	Romania
46	Cyprus	**85**	Italy	**153**	Slovakia
47	Czech Republic	**94**	Latvia	**154**	Slovenia
51	Denmark	**100**	Lithuania	**158**	Spain
58	Estonia	**101**	Luxembourg	**163**	Sweden
61	Finland	**108**	Malta	**179**	UK
62	France	**120**	Netherlands		
67	Germany	**127**	Norway		

Región: América Latina y el Caribe (ACL)

Eora26 Numbering	Country	Eora26 Numbering	Country	Eora26 Numbering	Country
6	Antigua	**41**	Colombia	**111**	Mexico
7	Argentina	**43**	Costa Rica	**124**	Nicaragua
9	Aruba	**45**	Cuba	**131**	Panama
13	Bahamas	**53**	Dominican Republic	**133**	Paraguay
16	Barbados	**56**	El Salvador	**134**	Peru
19	Belize	**71**	Guatemala	**146**	Sao Tome and Principe
21	Bermuda	**73**	Guyana	**171**	Trinidad and Tobago
23	Bolivia	**74**	Haiti	**182**	Uruguay
27	British Virgin Islands	**75**	Honduras	**185**	Venezuela
39	Chile	**86**	Jamaica		

Region: Rest of the World (RoW)					
Eora26 Numbering	Country	Eora26 Numbering	Country	Eora26 Numbering	Country
1	Afghanistan	**78**	Iceland	**132**	Papua New Guinea
2	Albania	**80**	Indonesia	**135**	Philippines
3	Algeria	**81**	Iran	**138**	Qatar
4	Andorra	**82**	Iraq	**139**	South Korea
5	Angola	**84**	Israel	**140**	Moldova
8	Armenia	**87**	Japan	**143**	Rwanda
10	Australia	**88**	Jordan	**144**	Samoa
12	Azerbaijan	**89**	Kazakhstan	**145**	San Marino
14	Bahrain	**90**	Kenya	**147**	Saudi Arabia
15	Bangladesh	**91**	Kuwait	**148**	Senegal
17	Belarus	**92**	Kyrgyzstan	**149**	Serbia
20	Benin	**93**	Laos	**150**	Seychelles
22	Bhutan	**95**	Lebanon	**151**	Sierra Leone
24	Bosnia and Herzegovina	**96**	Lesotho	**152**	Singapore
25	Botswana	**97**	Liberia	**155**	Somalia
28	Brunei	**98**	Libya	**157**	South Sudan
30	Burkina Faso	**99**	Liechtenstein	**159**	Sri Lanka
31	Burundi	**102**	Macao SAR	**160**	Sudan
32	Cambodia	**103**	Madagascar	**161**	Suriname
33	Cameroon	**104**	Malawi	**162**	Swaziland
35	Cape Verde	**105**	Malaysia	**164**	Switzerland
36	Cayman Islands	**106**	Maldives	**165**	Syria
37	Central African Republic	**107**	Mali	**166**	Taiwan
38	Chad	**109**	Mauritania	**167**	Tajikistan
42	Congo	**110**	Mauritius	**168**	Thailand
44	Croatia	**112**	Monaco	**169**	TFYR Macedonia
48	Cote d'Ivoire	**113**	Mongolia	**170**	Togo
49	North Korea	**114**	Montenegro	**172**	Tunisia
50	DR Congo	**115**	Morocco	**173**	Turkey
52	Djibouti	**116**	Mozambique	**174**	Turkmenistan
55	Egypt	**117**	Myanmar	**175**	Former USSR
57	Eritrea	**118**	Namibia	**176**	Uganda
59	Ethiopia	**119**	Nepal	**177**	Ukraine
60	Fiji	**121**	Netherland Antilles	**178**	UAE
63	French Polynesia	**122**	New Caledonia	**180**	Tanzania
64	Gabon	**123**	New Zealand	**183**	Uzbekistan
65	Gambia	**125**	Niger	**184**	Vanuatu
66	Georgia	**126**	Nigeria	**186**	Vietnam
68	Ghana	**128**	Gaza Strip	**187**	Yemen
72	Guinea	**129**	Oman	**188**	Zambia
76	Hong Kong	**130**	Pakistan	**189**	Zimbabwe

ANNEX B

Table B1: Volume of CO_2 emissions, by regions and years (Gigagrams)

		ECU	LAC	NA	EU	BRICS	RoW	EPP
ECU	**2000**	14039.93	1629.07	1676.28	826.66	291.21	1035.80	19498.95
	2008	22721.32	2563.25	2293.92	1303.64	622.98	1377.76	30882.86
	2015	33322.58	3146.58	2021.90	1098.19	727.12	1432.72	41749.09
LAC	**2000**	1126.29	777170.22	119002.88	21951.04	13286.52	16552.68	949089.63
	2008	2414.86	919661.61	146601.10	34495.77	35565.54	25597.30	1164336.18
	2015	3356.06	1029958.92	132965.62	27658.54	39290.15	25174.67	1258403.97
NA	**2000**	1407.59	113017.63	5843364.24	181087.11	51096.17	235314.38	6425287.12
	2008	2401.97	133876.58	5520792.89	211830.15	93617.77	260720.01	6223239.37
	2015	3145.64	139344.14	5033514.99	172683.93	121978.80	257030.53	5727698.02
EU	**2000**	528.97	34862.58	223401.38	3546746.20	68797.49	243777.60	4118114.23
	2008	899.33	40949.88	207320.86	3430125.82	139042.90	311016.50	4129355.29
	2015	1083.43	41062.18	159701.07	2825348.49	165932.62	299113.09	3492240.87
BRICS	**2000**	700.39	61785.18	490412.32	626972.69	5167020.85	680015.63	7026907.07
	2008	2159.47	119537.55	835746.28	982687.40	8626032.26	1266521.53	11832684.49
	2015	2975.79	142309.56	759025.28	874402.42	12582580.42	1399722.77	15761016.24
RoW	**2000**	750.86	46651.61	465000.88	531406.62	256386.49	4830628.43	6130824.90
	2008	1217.28	58683.67	478308.91	611477.78	515146.94	5960574.31	7625408.90
	2015	1622.52	66299.49	420900.89	537264.40	668317.12	6910084.30	8604488.71
Carbon footprint	**2000**	18554.02	1035116.30	7142857.99	4908990.34	5556878.72	6007324.52	**24669721.89**
	2008	31814.24	1275272.53	7191063.96	5271920.56	9410028.39	7825807.40	**31005907.08**
	2015	45506.01	1422120.87	6508129.75	4438455.97	13578826.23	8892558.08	**34885596.90**
Import.	**2000**	4514.09	257946.08	1299493.75	1362244.13	389857.87	1176696.09	
	2008	9092.92	355610.93	1670271.07	1841794.74	783996.13	1865233.09	
	2015	12183.43	392161.94	1474614.75	1613107.49	996245.80	1982473.78	
Export.	**2000**	5459.02	171919.41	581922.88	571368.02	1859886.22	1300196.47	
	2008	8161.54	244674.57	702446.48	699229.46	3206652.23	1664834.59	
	2015	8426.51	228445.04	694183.03	666892.38	3178435.82	1694404.41	
EEIT	**2000**	9973.11	429865.49	1881416.62	1933612.15	2249744.09	2476892.56	
	2008	17254.46	600285.50	2372717.55	2541024.20	3990648.36	3530067.68	
	2015	20609.93	620606.98	2168797.79	2279999.87	4174681.62	3676878.20	
ETB	**2000**	944.93	-86026.67	-717570.87	-790876.11	1470028.35	123500.38	
	2008	-931.37	-110936.35	-967824.59	-1142565.28	2422656.09	-200398.50	
	2015	-3756.92	-163716.90	-780431.72	-946215.10	2182190.01	-288069.37	

Source: Own elaboration

Note: The data in the Diagonal correspond to the Self-consumption of domestic trade, the data on the horizontal level concern exports to the distinct regions, and the data on the vertical level are the imports of the country from the distinct origin regions.

Table B2. Breakdown of the CF

		Direct CF	Domestic indirect CF	Import indirect CF	CF
Primary Sector	2000	170.96	360.26	183.50	714.72
	2008	323.74	431.90	335.16	1090.80
	2015	640.37	533.60	426.70	1600.68
Secondary Sector	2000	1962.03	1836.85	2146.65	5945.54
	2008	2809.47	3028.56	4114.99	9953.02
	2015	4564.71	4098.34	5589.40	14252.44
Electricity, Gas and Water	2000	968.08	105.56	40.87	1114.51
	2008	1953.65	150.16	70.12	2173.93
	2015	2905.41	215.47	94.58	3215.46
Construction	2000	328.16	947.21	367.35	1642.73
	2008	508.85	1452.26	781.24	2742.35
	2015	715.40	1973.02	932.00	3620.43
Hotels and Trade	2000	27.77	183.18	49.15	260.10
	2008	59.32	322.72	96.04	478.09
	2015	121.37	423.62	106.50	651.50
Transport	2000	5645.71	672.99	1418.28	7736.99
	2008	8560.75	925.87	3000.10	12486.72
	2015	12611.36	1310.56	4218.77	18140.68
Other Services	2000	114.21	716.86	270.60	1101.68
	2008	420.07	1773.81	624.07	2817.96
	2015	962.94	2246.13	710.93	3920.01
Re-export & re-import	2000	0.00	0.07	37.68	37.75
	2008	0.00	0.18	71.19	71.37
	2015	0.00	0.28	104.54	104.82

Table B3. Import indirect CF

		LAC	NA	EU	BRICS	RoW	TOTAL
Primary Sector	2000	46.94	56.87	22.95	23.13	33.61	183.50
	2008	94.83	95.01	35.57	60.14	49.62	335.16
	2015	124.75	117.20	39.33	79.34	66.09	426.70
Secondary Sector	2000	526.33	559.57	293.73	411.64	355.38	2146.65
	2008	1016.30	749.54	475.88	1291.06	582.21	4114.99
	2015	1424.95	952.04	586.11	1830.14	796.16	5589.40
Electricity, Gas and Water	2000	9.05	9.34	4.53	6.35	11.60	40.87
	2008	17.22	15.81	6.92	17.41	12.76	70.12
	2015	21.98	18.19	7.52	22.66	24.23	94.58
Construction	2000	98.12	84.34	50.66	73.59	60.64	367.35
	2008	219.86	129.24	88.29	238.37	105.48	781.24
	2015	271.14	145.93	90.86	304.21	119.86	932.00
Hotels and Trade	2000	12.41	13.01	6.43	6.99	10.31	49.15
	2008	25.40	21.57	10.77	21.23	17.07	96.04
	2015	28.23	22.39	10.22	24.90	20.77	106.50
Transport	2000	369.63	611.83	107.52	117.54	211.76	1418.28
	2008	890.46	1248.13	201.71	333.30	326.49	3000.10
	2015	1309.45	1729.86	264.40	475.33	439.74	4218.77
Other Services	2000	62.84	68.45	30.18	50.50	58.63	270.60
	2008	147.52	135.17	59.20	173.81	108.37	624.07
	2015	171.10	149.53	57.53	201.46	131.31	710.93
Re-export & re-import	2000	0.96	4.18	12.97	10.63	8.94	37.68
	2008	3.25	7.51	20.99	24.15	15.29	71.19
	2015	4.46	10.51	27.47	37.75	24.36	104.54