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Isolating economies. Is trade a large CO_2 driver?

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Measuring GHG emissions on a consumption-based approach allow us capturing the whole life-cycle impact of products and services across international supply chains. Historically, international trade has played a significant role in economic development. However, without fully and uniformly capturing the cost of externalities, production may occur in regions with poor environmental performance or weak environmental legislation. In this work we calculate the GHG emissions under the isolated economies principle, and compare the change respect to former calculations. Results from a fully coupled Multi Regional Input-Output model are presented, using 2004 global economic data disaggregated into 113 regions and 57 sectors. Two scenarios have been developed (reference and isolated) in order to calculated the change in GHG emissions embodied in final demand imports. Globally, there is a slight decrease of 18 Mt. Nevertheless, this slight difference hides important pollution interchanges. Results are broken down by national economic level, GHG emissions assignable to Annex 1 countries would decrease by 434 Mt and increase by 416 Mt in non-Annex 1. From an environmental point of view there are countries were production must be allocated domestically rather than abroad. A green border-tax would help countries like the United States and Japan to cut-off GHG emissions by over 110 Mt each. Through the analysis of sectors, a reduction of 209 Mt can be achieved by isolating electricity in each Annex 1 country. The lack of political interest in consumption-based emissions seems to have prevented from taking adequate and responsible decisions. This study further reinforces the need for consumption-based inventories to widen the scope of policies.

Keywords: Input-Output analysis; Emissions embodied; Emissions embedded

1 INTRODUCTION

Emissions embodied in international trade have been an actively research topic in the last decade. The results obtained allow us to calculate the so-called "consumption-based" emissions. Greenhouse gas (GHG) emissions can be allocated to a country in different ways, production-, territorial- and consumption-based emission reporting (Peters, 2008). There is a marked difference in end results depending on the chosen system. For example, the United Kingdom territorial-based emissions have shown a 19% reduction between 1990-2008. Conversely, consumption-based emissions show a 20% increase during the same period, which is driven by GHG emissions embodied in imported products (Wiedmann and Barrett, 2011)**.** Consumption-based emissions allocate them to the consumers in each country, usually based on final consumption as in the System of National Accounts but also as trade-adjusted emissions (Peters, 2008). Conceptually, consumption-based inventories can be thought of as production-based minus exports, plus imports. Territorial-based inventories are production-based ones without international aviation and shipping emissions.

The use of consumption-based inventories is commonly named Carbon Footprint. Carbon Footprint is described in detail by Galli et al., (2011) and defined as all anthropogenic GHG emissions which are directly or indirectly released during an activity or use of a product and accumulated over the life stages of a product or a set of products. The Carbon Footprint of a nation refers to Carbon Footprint of all products consumed by the nation.

Historically, international trade has played a significant role in economic development by giving a mechanism to efficiently allocate resources, typically labor and capital (Feenstra, 2003). However, without fully and uniformly capturing the cost of externalities, production may occur in regions with poor environmental performance or weak environmental legislation (Peters and Hertwich, 2008). This possibility, pointed out by Wyckoff and Roop (1994) years before the Kyoto Protocol was established, is the called “carbon leakage”. Carbon leakage refers to the carbon embodied in goods imported from countries without any GHG emissions reduction target, which escapes the control of the national GHG emissions estimates of the importing countries, although it contributes to the Global Warming being emitted in the exporting countries (Mongelli et al., 2006). As a result carbon-intensive industries are supposed to be sited in developing countries in direct response to climate policy (i.e., “strong” carbon leakage); however, industrial expansion occurring in those countries for other reasons (i.e., “weak” carbon leakage) may unintentionally undermine ongoing efforts to regulate emissions (Rothman, 1998; Peters et al., 2009; Weber and Peters, 2009; Davis and Caldeira, 2010).

Global warming agreements such as the Kyoto protocol and the European Emission Allowance Trading Scheme (EATS) follows the Intergovernmental Panel on Climate Change’s guidelines in terms of the allocation of GHG emissions “emissions and removals taking place within national (including administered) territories and offshore areas over which the country has jurisdiction” (IPCC, 1996, p. 5). According to this definition, the international agreements only consider the territorial-based emissions avoiding international aviation and shipping emissions and even the emissions embodied in international trade. This could represent a competitive disadvantage for the 39 Annex I countries and the European under EATS countries, since the measures and policies implemented in order to achieve the GHG emissions reduction target determine higher costs for the countries and the companies territorially involved. Therefore, the countries that do not take part in such agreements, non-Annex I or non-EATS countries, may become a haven for energy-carbon intensive industries (Mongelli et al., 2006).

Many authors (Peters et al. 2008, Aichele and Felbermayr, 2011) considered Kyoto has caused some domestic emission savings but there have been an increase in net imports of carbon so that the carbon footprint of countries has not changed.

In this context, the need to estimate consumption-based emissions has led the input–output analysis developed by Leontief (1941) as the most widely-used approach for studying GHG emissions embodied in international trade (Du et al., 2011). In the last decade there has been a remarkable increase in methodological progress, quality and quantity of underlying data and policy relevant applications (Wiedmann et al., 2011). The last progress in the methodology called Environmentally Extended Multi-Region Input-Output (EE-MRIO) analysis has been probed as a robust methodology for measuring GHG emissions on a consumption-based approach, capturing the whole life-cycle impact of products and services across international supply chains (Minx et al., 2009).

As shown in comprehensive reviews (Wiedmann et al., 2007; Wiedmann, 2009a), since the 1970s there has been a growing interest on the interactions between trade and environment and its estimation with input-output analysis. To our knowledge, the first EE-MRIO analysis to calculate the global GHG emissions on regional average were made by Lenzen et al. (2004), who calculated the trade balance taking into account five regions (Denmark, Germany, Sweden, Norway and the Rest of World). Since 2004 several studies have been made: Peters and Hertwich (2006a) analyzed the impact of Dutch household consumption considering the Netherlands and three different world regions, Peters and Hertwich (2006b) analyzed the environmental impacts of Norway's final demand aggregating all its trading partners into seven regions and Friot et al. (2007) analyzed the global GHG emissions on regional average aggregating the world into twelve regions. Lately, most common EE-MRIO studies were made considering 87 regions from GTAP database (Peters and Hertwich, 2008) to analyze CO_2 emissions embodied in international trade. Wilting and Vringer (2009) also included CH_4, N_2O and land use; Hertwich and Peters (2009) compared Carbon Footprints and Andrew et al. (2009) quantified errors induced by applying different assumptions. However, the principal drawback to this approach is the difficulty of getting the necessary and detailed data on interregional transactions; and when this information is available it should be cautiously used because of the lack of consistency and accuracy of some databases (Peters and Hertwich, 2008a). Moreover, in these multi-regional studies it is necessary to make some assumption about the technology of the Rest of World when it is considered as a region in the model. Nevertheless, all these studies are a sign of the importance of considering different technologies when estimating the emissions embodied in trade. The last methodological progress made in EE-MRIO has led to recent studies quantifying the emissions embodied in global trade (i.e., emitted during the production and transport of traded goods and services) (Mäenpää and Siikavirta, 2007; Chen and Chen, 2010; Davis and Caldeira, 2010; Serrano and Dietzenbacher, 2010; Su and Ang, 2011; Peters et al., 2011; Du et al., 2011).

Many of these empirical studies reported show that the emissions embodied in a country's international trade have been increasing over time. It has also been found that developed countries are generally net importers while developing countries are net exporters of emissions. Consumption-based emissions are currently not reported officially by any country, but they are increasingly estimated by researchers. Therefore, the consumption-based emission inventory has been considered as a possible alternative measure to the IPCC's territorial or production-based emission inventory (Serrano and Dietzenbacher, 2010; Su and Ang, 2011).

Emission embodied in trade can vary as a result of different model assumptions and data aggregation. Two types of data aggregation, i.e. sector aggregation and spatial aggregation, and their effects on estimating the emissions embodied in trade are studied in Su and Ang (2010a,b) respectively. These two aggregation issues are found to have significant impacts on the "transfer" of emissions between countries. On the other hand, two commonly model approaches have been made: Emission Embedded in Bilateral Trade (EEBT) and EE-MRIO. Both approaches applied to measure the embodied emissions are constructed based on different assumptions and have different data requirements. The EEBT is based on single-region Input-Output tables instead of the full multi-regional table used by EE-MRIO (Wiedmann et al., 2007). Peters (2008) treats these two general approaches, i.e. EEBT approach and the EE-MRIO approach, to measure embodied emissions at the national level. The main difference between them lies in the treatment of imported products for intermediate consumptions, which is related to the feedback effects in the Input Output literature. In the EEBT approach, domestic technologies are applied to the domestic production of each region but these technologies do not apply to its imports. This approach has the transparency property and is superior when analyzing trade and climate policy. For a complete discussion see Su and Ang, (2011) and Peters (2008).

Given the significant meaning, there is an emerging demand for embodied in trade GHG emissions studies, especially on the global level with international negotiations, cooperation and conflicts on climate change issues appearing more and more frequently. In this work, following the lines opened by the above authors, we calculate GHG emissions under the isolated economies principle, and compare the change respect to former calculations. This has been made in order to answer the question if international trade is a global GHG emissions driver. This change in trade patterns is relevant in order to justify the increasing interest in using trade-based mechanisms such as green border-tax adjustments (Ismer and Neuhoff, 2004; Monjon and Quirion, 2010; Dissou and Eyland, 2011).

All these analysis have been done using the EE-MRIO model. The use of this model allows us to answer how GHG emissions embodied in final demand imports can be affected by changes in trade patterns at country, region or global level. This article answer two relevant questions: firstly, how global GHG emissions would be increased or decreased by the effect of isolating economies and secondly, how countries and sectors are affected. The details of this analytic approach are described in Materials and Methods.

2 MATERIALS AND METHOD

Input-Output analysis is a well-established linear economic model often used to account for economic and environmental consequences or impacts following a change in the total output produced by the economy. The main reference for methodological foundations are in Miller and Blair (2009). The Input-Output model can be used as an analysis tool either at macro- or micro-level (Mongelli et al., 2002; Suh, 2004).

Considering the economy of n sectors and m regions, the Multi Regional Input-Output analysis is based on the use of Domestic Input–Output tables and international trade data in order to build a fully coupled a Multi-Regional Input-Output Table (MRIOT). Its main feature is the ability of describing an economic system in a steady-state period, usually one year. Each column of the MRIOT, which corresponds to a sector in a specific region, describes the quantities of all the other commodities used as input by that sector in that region; while each row shows the distribution of the output of a sector in a specific region to the other ones sectors in regions. Everything produced by a sector is purchased and consumed as inputs by other sectors or by the consumer as final demand (i.e., final demand, as opposed to the intermediate demand of industry for raw materials or unfinished goods). In matrix notation this system of linear equations is

$$X = Z + Y \tag{1}$$

Where X is the total output, Y is the final demand and Z is the intermediate demand with all domestic matrix (i.e. economy transactions inside the same region) in the diagonal and all the imports and exports matrix (i.e. economy transactions between the different region) off the diagonal. Everything is estimated in basic prices (i.e. price when goods leave the factory excluding the value added and other taxes on the product). In order to determine a new total output for a new given final demand, it is necessary to calculate the technological matrix A. Its coefficients (reading the matrix by columns) represent the outputs of the sectors in each region required and purchased as input by another sector in each region to produce one unit of its monetary output.

$$A = Z/diag(X_j) \tag{2}$$

Thus, if we suppose that *j* is the wood products sector from country *r* and *i* the forestry sector in country *s*, the element of A (a_{ij}^{rs}) represents the quantity of forestry sector from country *r* (in monetary unit) used by the wood products sector in country *s* to produce one unit of its monetary output.

$$X = AX + Y \tag{3}$$

In the more traditional block form the normalized MRIOT is obtained,

$$\begin{pmatrix} X^1 \\ X^2 \\ \vdots \\ X^m \end{pmatrix} = \begin{pmatrix} A^{11} & A^{12} & \dots & A^{1m} \\ A^{21} & A^{22} & \dots & A^{2m} \\ \vdots & \vdots & \ddots & \vdots \\ A^{m1} & A^{m2} & \dots & A^{mm} \end{pmatrix} \begin{pmatrix} X^1 \\ X^2 \\ \vdots \\ X^m \end{pmatrix} + \begin{pmatrix} Y^1 \\ Y^2 \\ \vdots \\ Y^m \end{pmatrix} \tag{4}$$

assuming every A matrix are square matrix of n-by-n size. Y matrix are normally n-by-1 size, but it depends on the disaggregation of the final demand, generally disaggregated in: government, capital formation, household and others. X matrix are normally n-by-1 size. A matrix are endogenous variable treated as constants. Exogenous changes are made in Y matrix, which implies a reaction of the economic system, generating a new output in each economic sector for each region both directly and indirectly involved. The total output is given by solving:

$$X = (I - A)^{-1}Y = LY \quad (5)$$

Where I is the identity matrix and L is the well-known Leontief inverse. As already mentioned, the Input‑Output model can be used to account for environmental impacts, such as resources use and pollution, due to an arbitrary and exogenous change in the final demand. This environmental extension of the basic Input-Output model can be obtained by introducing a further matrix F, which includes, for each region and sector, direct resource use and pollutants emissions for one unit of their monetary output (Miller and Blair, 2009). The multiplication of the environmental matrix F and the Leontief inverse L gives the total multiplier matrix M, which shows the total (direct plus indirect) resources and pollutants intensity of each sector in each region. The final multiplication of M and Y gives E. E is the total environmental impacts (resulting resource use and pollutants emissions) from the whole production phase of the arbitrary final demand Y.

$$E = FLY = MY \quad (6)$$

The GTAP database (GTAP, 2007; Burniaux and Truong, 2008) is currently the most suitable dataset available for the construction of an MRIOT, since it is the only one which includes consistent bilateral trade data (Weinzettel et al., 2011). GTAP is based on datasets provided by a worldwide network of national dataset providers as well as the UN Commodities Trade Database (UN Statistics, 2008). With 57 sectors and 113 regions (in practice, most regions in the present analysis are individual countries), the simulated network for this study has 6441×6441 trading flows. The fully coupled MRIOT has been built by the Stockholm Environmental Institute (REFERENCE?) according to methodology later described in Peters et al. (2011).

In order to calculate Carbon Footprint using EE-MRIO analysis it is required direct GHG emissions released by individual economic sectors in all regions. The GHG emissions available in the GTAP database do not correspond to other data sources on CO_2 emissions and do not include non-fossil CO_2 emissions from several sources, such as cement production and bunker fuels. Therefore, we utilize data provided under the 7th Framework Programme for Research and Technological Development (Weinzettel et al., 2011). This framework uses the data provided by Carbon Dioxide Information Analysis Center to adjust total national GHG emissions from fossil fuels as proposed by Davis and Caldeira (2010). Furthermore, they include non-energy CO_2 emissions from cement production and gas flaring. The units used within the model are CO_2-eq calculated using coefficients provided by IPCC for global warming potential over a 100 year perspective (commonly referred to as GWP100). In this analysis, CO_2 emissions from biomass are considered climate neutral and therefore they are not included in the Carbon Footprint.

In order to calculate the Carbon Footprint embodied in international trade we have used similar approach applied by (Hertwich and Peters, 2009) and (Davis and Caldeira, 2010). It can be calculated due to an exogenous change in the final demand, which can be changed arbitrarily according to different scenarios. The two scenarios created focus only on the GHG emissions embodied in final demand imports; therefore, all domestic final demand (i.e. all products final generated and consumed by the same region) are considered null (i.e. in the traditional block form the new 6441-by-113 Y matrix obtained has null 57-by-1 matrix in the diagonal). The consequence of this assumption is all emissions related to intermediate demand import and finally generated and consumed domestically are neglected. Therefore, our figures are lower than the commonly known emissions embodied in international trade.

Reference scenario, defined as above, compromise all emissions embodied in final demand imports. Isolated scenario is defined by assuming all the final demand imports produced domestically. Therefore all final demand imports are summed and allocated in the diagonal matrix (i.e. in the traditional block form the new 6441-by-113 Y matrix obtained has all zeros except the block 57-by-1 size matrix in the diagonal).

The use of EE-MRIO have some general assumptions that must be considered, this are described in Wiedmann et al. (2011). For this study it is supposed the same structure between scenarios and therefore the available of technology and resources for produce every final demand import as domestic. A negative difference from reference to isolated scenario would mean a decrease in GHG emissions. It would reflect a cleaner domestic economy; this is supposed to be in developed countries where they normally have less carbon intensive technologies. On the contrary developing countries are supposed to have an increase in GHG emissions from reference to isolated scenario. This positive difference reflects more carbon intensive economies. Because the approach is consumption-based emissions all final demand trade is considered as import, there is no need to use emissions embodied in final demand exports.

3 RESULTS

We present results from a fully coupled EE-MRIO model constructed from 2004 global economic data disaggregated into 113 regions and 57 sectors. Two scenarios have been developed (reference and isolated) in order to calculate the emissions avoided or increased by the phenomenon of isolating economies.

The first column in all tables presented shows the emissions embodied in final demand imports that must be allocated to the country according to consumption-based emission inventories. The second columns are these results for the isolated economies scenario. Changes between scenarios are measured in relative and absolute value.

From a global point of view, the results show a negative slight difference. Emissions embodied in trade would be 0.70% lower (a decrease of 18.15 megatonnes (Mt) of GHG emissions embodied in final demand imports). Nevertheless as can be seen in region disaggregated (Tables 1 and 2), the positive global slight difference hides important pollution interchanges.

From a region point of view (Table 1 and 2), GHG emissions embodied in final demand imports assignable to Annex 1 countries would be 23.01% lower (a decrease of 433.88 Mt GHG emissions embodied in final demand imports). On the other hand emissions embodied in final demand imports assignable to non-Annex 1 countries would be 59.66% higher (an increase of 415.73 Mt GHG emissions embodied in final demand imports).

Looking in Annex 1 countries (Table 1), regions with higher negative difference are United States and Japan. United States would reduce the largest amount of GHG emissions (a decrease of 111.14 Mt GHG emissions embodied in final demand imports); on the contrary Japan and Sweeden would be the countries with lower relative results (a reduction near to 60% of GHG emissions embodied in imports). There are countries (in Annex 1 with positive difference (11 out of 39 countries). Russia is by far the Annex 1 country with large positive difference for isolating the economies, the isolating phenomenon would near triplicate its GHG emissions embodied in imports.

Inside non-Annex 1 (Table 2) China is by far the country with larger positive difference of isolating the economies. Its GHG emissions embodied in imports would be almost quadruple the reference GHG emissions (an increase of 152.59 Mt GHG emissions embodied in imports). The differences between countries in non-Annex 1 countries are larger. There are a considerable amount of regions with negative difference (34 out of 74 regions considered).

Summing regions and breaking down the results to the 57 sectors considered (Tables 3, 4 and 5) offers the following results. From a global point of view (Table 3) there are 31 sectors with negative difference. Electricity sector is by far the sector with larger negative difference (a decrease of 47.59 Mt GHG emissions embodied in imports). From a relative point of view 1) Oil seeds 2) Paddy rice and 3)Textiles sectors have the higher relative decrease due to isolating the economies. The sectors with positive difference are 1)Machinery and equipment not elsewhere classified (nec) 2) Transport nec and 3)Chemical, rubber, plastic products. From a relative point of view 1) Machinery and equipment nec 2)Electronic equipment 3) Motor vehicles and parts are the sectors with higher relative increase produced by isolating the economies.

Regarding sectors in Annex 1 countries (Table 4) there are only 7 sectors with positive difference due to isolating the economies. The sector with larger negative effect by isolating economies is electricity (a decrease of 209.10 Mt of GHG emissions embodied in imports). From relative point of view coal sector is the sector with higher relative decrease. The sector with larger positive effect by isolating economies is motor vehicles and parts (an increase of 0.49 Mt of GHG emissions embodied in imports). From relative point of view wool, silk-worm cocoons are the sector with higher relative increase.

Regarding sector in non-Annex 1 countries (Table 5) there are 41 sectors with positive difference due to isolating the economies. From the few sectors with negative difference by isolating economies, textiles is the sector with larger absolute value (a decrease of 1.79 Mt of GHG emissions embodied in imports). From relative point of view oil seeds is the sector with higher relative decrease. The sector with larger positive difference by isolating economies is electricity (an increase of 161.51 Mt of GHG emissions embodied in imports). From relative point of view wearing apparel is the sector with higher relative increase.

4 DISCUSION

The results of this study are generally consistent with those from (Peters and Hertwich, 2008; Davis and Caldeira, 2010; Chen et al., 2010; Su and Ang, 2011) minor discrepancies occur meanly due to GHG emissions categories inclusion. When interpreting the results presented it must be considered we refer to emissions embodied in final demand imports, i.e. all the imports for intermediate demand and finally consumed domestically are neglected. Therefore our figures are lower than the published in above authors.

In accordance with Peters and Hertwich (2008) from a global climate change perspective we agree it is more desirable to have production occur where it is environmentally preferable and then trade the products internationally. This study shows sectors and countries that may have a large increase or decrease by the effect of isolating the economy. For example, despite trade has played a significant role in economic development from a global point of view we found that sectors like electricity (production, collection and distribution) would have a global carbon benefit due to isolating economies. This benefit would be more than 4 times larger (a decrease of 209.10 Mt of GHG emissions embodied in final demand imports) if we only isolated electricity sector in every Annex 1 countries. Another sectors with high effect are 1)Chemical, rubber, plastic; 2)Mineral products nec; 3)Ferrous metals; 4)Petroleum, coal products. This reinforce already said in Peters and Hertwich (2008), without fully and uniformly capturing the cost of externalities, production may occur in regions with poor environmental performance or weak environmental legislation.

Regarding the debate about green border-tax discussed by (Ismer and Neuhoff, 2004; Monjon and Quirion, 2010; Dissou and Eyland, 2011). This paper shows United States and Japan as the countries where green border-tax adjustments and therefore restrictions in imports would have large possibilities for decrease GHG emissions embodied in final demand imports. Nevertheless most Annex 1 countries (28 countries out of the 39 countries considered) would have reductions in GHG emissions embodied in final demand imports by the effect of isolating the economies. On the contrary there are countries like China that its isolation would increase its emissions embodied in final demand imports near to 4 times actual GHG emissions embodied in final demand imports (152.59 Mt GHG emissions in final demand imports). When interpreting these results in a country point of view, it must be considered there would be positive effect in the perspective of production-based inventories due to the suspension of exports in isolated economies scenario.

If an international climate regime has limited participation, such as in the Kyoto Protocol and the actual implementation of the EATS, the problem of carbon leakage arises. Without going to discuss between strong or weak carbon leakage there is a topic that must be farther discuss. This study reinforces the argument of why from an environmental point of view there are countries were production must be located domestically rather than imported. For example, according to this study, if Annex 1 countries stop importing final demand products there would be a decrease in GHG emissions of 433.88 Mt. This is a large figure that must consider in order to prevent the actual carbon leakage for the allocation of carbon-intensive industries in developing countries.

According to (Su and Ang, 2011) emission embodied in trade vary between the EEBT and EE-MRIO approaches. The differences should have been reported in this study but the lack of data for considering the EEBT need further surveys. Moreover a study under EEBT would have considered all emissions embodied in trade (i.e. not only final demand trade) and would have given us a complete picture of these two scenarios. It must also be considered the necessity of and updated MRIOT as well as the implementation under news MRIOT made e.g. from the Organisation for Economic Co-operation and Development database.

According to the latest study (Aichele & Felbermayr, 2011), emissions embodied in international trade flows are quantitatively important: in 1995, about 16% of emissions were traded; in 2007 this measure is up to 21%. Many authors considered despite the domestic emission savings there have been an increase in net imports of GHG emissions so that the carbon footprint of countries has not changed. Sharing responsibility for emissions among producers and consumers could facilitate international agreements on global climate policy that is now hindered by concerns over the regional and historical inequity of emissions (Davis & Caldeira, 2010). This is possible under the EE-MRIO a robust methodology for measuring GHG emissions on a consumption-based approach. The lack of policy interest avoids taken responsible decisions. This study further reinforces the need to account for consumption-based emissions to widen the scope of policies, and make tailor these policies in a suitable manner that may not have been considered otherwise. Governments and citizens should demand international agreements which considered consumer-based inventories.

5 ACKNOWLEDGEMENTS

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Table 1: Annex 1 emissions embodied in final demand imports. Change by countries

	Scenarios		Change	
Region	**Reference (Mt GHG)**	**Isolated (Mt GHG)**	**Absolute (Mt GHG)**	**Relative (%)**
United States	523.27	412.13	-111.14	78.76
Germany	200.32	114.39	-85.92	57.11
Japan	184.61	74.22	-110.39	40.20
United Kingdom	154.82	84.01	-70.81	54.26
France	109.78	52.45	-57.33	47.78
Canada	77.39	66.42	-10.97	85.82
Italy	69.30	55.66	-13.64	80.32
Spain	57.33	44.22	-13.11	77.13
Russia	56.22	152.99	96.76	272.11
Netherlands	49.83	32.46	-17.37	65.14
Belgium	44.41	36.10	-8.31	81.30
Australia	41.31	32.85	-8.46	79.52
Switzerland	31.90	18.02	-13.88	56.49
Turkey	30.73	34.48	3.75	112.21
Austria	29.96	17.12	-12.85	57.12
Sweden	24.88	9.68	-15.20	38.91
Greece	21.37	16.24	-5.13	75.98
Poland	19.41	33.51	14.10	172.66
Denmark	19.29	10.12	-9.17	52.46
Norway	14.47	7.35	-7.12	50.80
Ireland	14.14	9.87	-4.27	69.79
Ukraine	13.24	35.82	22.58	270.63
Portugal	13.09	10.29	-2.80	78.61
Finland	12.69	9.70	-2.99	76.43
Czech Republic	11.89	16.42	4.53	138.14
Hungary	9.07	7.71	-1.36	85.04
New Zealand	7.65	6.16	-1.49	80.56
Romania	7.55	13.41	5.85	177.46
Croatia	5.50	6.17	0.67	112.17
Slovakia	5.09	5.82	0.73	114.33
Luxembourg	4.74	3.61	-1.13	76.11
Belarus	3.99	6.36	2.37	159.38
Lithuania	3.61	3.07	-0.55	84.89
Slovenia	3.10	2.62	-0.47	84.67
Latvia	3.04	2.54	-0.50	83.46
Estonia	2.33	3.68	1.36	158.22
Rest of EFTA	1.53	0.87	-0.65	57.24
Bulgaria	1.26	1.97	0.70	155.86
Malta	1.18	0.89	-0.29	75.71
Total Annex 1	1,885.27	1,451.39	-433.88	76.99

Table 2: Non-Annex 1 emissions embodied in final demand imports. Change by countries

Region	Scenarios		Change	
	Reference (Mt GHG)	Isolated (Mt GHG)	Absolute (Mt GHG)	Relative (%)
China	54.41	207.00	152.59	380.46
Mexico	52.31	43.48	-8.84	83.11
Hong Kong	40.82	22.11	-18.71	54.17
Korea	36.90	35.08	-1.82	95.06
Taiwan	28.55	39.41	10.87	138.07
India	25.00	56.51	31.51	226.03
Singapore	22.35	20.09	-2.27	89.86
Indonesia	19.49	28.49	9.00	146.18
Caribbean	19.43	16.42	-3.01	84.53
Malaysia	19.27	24.99	5.72	129.68
Thailand	18.55	29.69	11.14	160.04
Iran	17.18	59.15	41.98	344.39
Brazil	16.87	18.71	1.84	110.92
Pakistan	14.07	29.13	15.06	207.05
South Africa	12.83	29.85	17.01	232.57
Nigeria	12.22	18.20	5.99	149.02
Rest of Western Africa	11.25	10.94	-0.31	97.22
Rest of North Africa	10.66	18.77	8.11	176.11
Kazakhstan	9.87	27.50	17.63	278.53
Philippines	8.99	8.90	-0.09	98.97
Vietnam	8.72	20.75	12.04	238.04
Rest of Europe	6.88	18.02	11.14	262.02
Argentina	6.62	13.93	7.31	210.40
Chile	6.19	9.88	3.70	159.73
Peru	6.06	3.07	-2.99	50.70
Rest of Eastern Africa	5.95	3.82	-2.13	64.28
Colombia	5.49	5.19	-0.30	94.52
Morocco	5.33	4.96	-0.37	93.03
Bangladesh	5.23	3.36	-1.87	64.24
Rest of Soviet Union	4.90	23.86	18.96	487.03
Sri Lanka	4.72	4.56	-0.15	96.76
Venezuela	4.65	11.33	6.69	243.99
Azerbaijan	4.23	13.66	9.43	323.23
Rest of South Africa	4.06	4.14	0.08	101.91
Rest of Central America	3.94	4.15	0.21	105.24
Ecuador	3.52	4.48	0.96	127.14
Guatemala	3.32	2.98	-0.34	89.66
Rest of Oceania	3.32	3.28	-0.03	98.98
Tunisia	3.29	3.94	0.64	119.51

Panama	3.11	1.70	-1.40	54.83
Rest of East Asia	2.96	8.32	5.36	281.09
Rest of South Asia	2.88	1.90	-0.98	65.97
Rest of Eastern Europe	2.64	2.83	0.19	107.19
Cyprus	2.43	2.25	-0.18	92.65
Rest of South African	2.35	1.46	-0.89	62.26
Botswana	2.34	1.56	-0.78	66.59
Ethiopia	2.34	2.46	0.12	104.92
Costa Rica	2.07	1.40	-0.67	67.79
Rest of Central Africa	2.03	1.00	-1.03	49.46
Tanzania	2.01	1.31	-0.70	65.07
Georgia	1.71	1.05	-0.66	61.14
Mauritius	1.67	0.99	-0.68	59.34
Egypt	1.48	2.84	1.36	191.85
Myanmar	1.46	2.38	0.91	162.38
Rest of North America	1.34	1.02	-0.33	75.75
Kyrgyzstan	1.33	2.18	0.84	163.30
Paraguay	1.24	0.87	-0.37	69.86
Albania	1.22	1.03	-0.18	84.87
Senegal	1.19	0.87	-0.32	73.12
Uruguay	1.19	1.19	0.00	100.41
Zimbabwe	1.12	2.03	0.91	181.28
Nicaragua	1.08	1.56	0.48	144.71
Mozambique	1.07	0.79	-0.28	74.09
Armenia	0.97	1.57	0.60	162.55
Zambia	0.86	0.41	-0.45	48.01
Bolivia	0.84	2.63	1.79	311.59
Rest of South America	0.75	1.44	0.69	191.35
Malawi	0.69	0.60	-0.09	86.98
Cambodia	0.66	0.95	0.29	143.64
Uganda	0.62	0.38	-0.24	61.51
Madagascar	0.45	0.38	-0.06	85.63
Laos	0.40	0.52	0.12	129.50
Rest of Southeast Asia	0.34	0.59	0.25	172.86
Rest of Western Asia	98.61	154.35	55.74	156.53
Total Non-Annex 1	696.88	1,112.61	415.73	159.66

Table 3: Global emissions embodied in final demand imports. Change by sectors

Sectors (short description)	Scenarios		Change	
	Reference (Mt GHG)	Isolated (Mt GHG)	Absolute (Mt GHG)	Relative (%)
Paddy rice	1,13	0,61	-0,52	0,54
Wheat	4,20	2,56	-1,64	0,61
Cereal grains nec	4,17	3,43	-0,74	0,82
Vegetables, fruit, nuts	11,83	8,75	-3,09	0,74
Oil seeds	5,02	2,49	-2,53	0,50
Sugar cane, sugar beet	0,78	0,49	-0,28	0,64
Plant-based fibers	4,18	2,69	-1,49	0,64
Crops nec	6,33	5,34	-0,99	0,84
Bovine cattle, sheep, goats, horses	1,94	1,33	-0,61	0,69
Animal products nec	4,42	2,46	-1,96	0,56
Raw milk	1,18	0,97	-0,21	0,82
Wool, silk-worm cocoons	0,96	1,26	0,29	1,31
Forestry	3,98	2,71	-1,27	0,68
Fishing	8,03	6,47	-1,56	0,81
Coal	15,50	8,77	-6,73	0,57
Oil	23,61	21,86	-1,75	0,93
Gas	19,09	23,55	4,46	1,23
Minerals nec	16,19	16,88	0,69	1,04
Bovine meat products	1,46	1,69	0,23	1,16
Meat products nec	1,66	1,81	0,15	1,09
Vegetable oils and fats	4,44	4,75	0,31	1,07
Dairy products	2,42	2,90	0,48	1,20
Processed rice	1,52	0,90	-0,62	0,59
Sugar	1,51	2,01	0,50	1,33
Food products nec	15,42	13,19	-2,23	0,86
Beverages and tobacco products	3,48	4,35	0,87	1,25
Textiles	30,32	16,50	-13,82	0,54
Wearing apparel	7,55	9,27	1,72	1,23
Leather products	4,62	3,70	-0,91	0,80
Wood products	4,95	4,51	-0,44	0,91
Paper products, publishing	27,92	27,29	-0,64	0,98
Petroleum, coal products	90,80	96,36	5,56	1,06
Chemical, rubber, plastic	198,41	215,15	16,74	1,08
Mineral products nec	88,02	71,34	-16,69	0,81
Ferrous metals	133,38	142,68	9,30	1,07
Metals nec	33,54	33,91	0,37	1,01
Metal products	10,00	11,80	1,80	1,18
Motor vehicles and parts	10,78	16,70	5,92	1,55
Transport equipment nec	5,88	7,21	1,33	1,23

Electronic equipment	13,08	22,02	8,94	1,68
Machinery and equipment nec	30,53	53,50	22,97	1,75
Manufactures nec	12,87	14,99	2,12	1,16
Electricity	1155,04	1107,45	-47,59	0,96
Gas manufacture, distribution	17,83	15,08	-2,75	0,85
Water	2,36	2,84	0,48	1,21
Construction	2,59	2,81	0,22	1,09
Trade	29,45	29,37	-0,08	1,00
Transport nec	287,73	307,74	20,01	1,07
Water transport	47,82	41,22	-6,60	0,86
Air transport	131,96	126,69	-5,27	0,96
Communication	2,06	2,40	0,34	1,17
Financial services nec	3,13	3,37	0,24	1,08
Insurance	1,00	0,87	-0,13	0,87
Business services nec	17,77	18,78	1,00	1,06
Recreational and other services	7,33	6,32	-1,01	0,86
Public Administration, Defense, Education, Health	8,97	7,91	-1,06	0,88
Dwellings	0,00	0,00	0,00	0,52

nec: not elsewhere classified

Table 4: Annex 1 emissions embodied in final demand imports. Change by sectors

Sectors (short description)	Scenarios		Change	
	Reference (Mt GHG)	Isolated (Mt GHG)	Absolute (Mt GHG)	Relative (%)
Paddy rice	0,63	0,25	-0,38	0,40
Wheat	1,92	1,19	-0,73	0,62
Cereal grains nec	2,27	2,03	-0,23	0,90
Vegetables, fruit, nuts	9,58	7,21	-2,37	0,75
Oil seeds	2,90	1,33	-1,57	0,46
Sugar cane, sugar beet	0,47	0,28	-0,18	0,60
Plant-based fibers	3,03	1,84	-1,19	0,61
Crops nec	5,27	4,44	-0,83	0,84
Bovine cattle, sheep, goats, horses	1,46	0,97	-0,49	0,67
Animal products nec	3,47	1,84	-1,64	0,53
Raw milk	0,88	0,73	-0,15	0,83
Wool, silk-worm cocoons	0,72	1,10	0,38	1,52
Forestry	3,27	2,08	-1,19	0,64
Fishing	5,90	4,08	-1,82	0,69
Coal	11,31	3,22	-8,09	0,28
Oil	17,18	14,14	-3,05	0,82
Gas	14,16	14,50	0,34	1,02
Minerals nec	11,76	8,66	-3,10	0,74
Bovine meat products	1,12	1,10	-0,02	0,98
Meat products nec	1,35	1,29	-0,06	0,95
Vegetable oils and fats	2,19	1,70	-0,49	0,78
Dairy products	1,69	1,87	0,18	1,11
Processed rice	0,51	0,19	-0,32	0,37
Sugar	0,87	0,91	0,04	1,05
Food products nec	11,99	8,91	-3,08	0,74
Beverages and tobacco products	2,46	1,87	-0,58	0,76
Textiles	22,25	10,22	-12,02	0,46
Wearing apparel	6,35	4,20	-2,16	0,66
Leather products	3,89	2,50	-1,40	0,64
Wood products	4,15	3,38	-0,78	0,81
Paper products, publishing	20,71	14,82	-5,89	0,72
Petroleum, coal products	63,78	43,78	-20,00	0,69
Chemical, rubber, plastic	143,96	102,02	-41,94	0,71
Mineral products nec	63,85	35,73	-28,12	0,56
Ferrous metals	91,27	69,32	-21,94	0,76
Metals nec	23,42	18,90	-4,52	0,81
Metal products	7,47	6,96	-0,50	0,93
Motor vehicles and parts	9,02	9,51	0,49	1,05
Transport equipment nec	3,62	2,64	-0,98	0,73

Electronic equipment	9,49	7,72	-1,77	0,81
Machinery and equipment nec	20,69	16,89	-3,79	0,82
Manufactures nec	10,12	3,92	-6,20	0,39
Electricity	843,07	633,97	-209,10	0,75
Gas manufacture, distribution	13,08	6,53	-6,56	0,50
Water	1,78	1,79	0,01	1,00
Construction	2,02	1,85	-0,17	0,92
Trade	22,66	18,43	-4,23	0,81
Transport nec	219,02	219,22	0,20	1,00
Water transport	36,61	21,74	-14,88	0,59
Air transport	94,43	83,30	-11,13	0,88
Communication	1,59	1,16	-0,43	0,73
Financial services nec	2,38	2,19	-0,19	0,92
Insurance	0,78	0,56	-0,22	0,72
Business services nec	13,69	13,56	-0,12	0,99
Recreational and other services	5,69	3,26	-2,43	0,57
Public Administration, Defense, Education, Health	6,06	3,62	-2,44	0,60
Dwellings	0,00	0,00	-0,00	0,26

nec: not elsewhere classified

Table 5: Non-Annex 1 emissions embodied in final demand imports. Change by sectors

Sectors (short description)	**Scenarios**		**Change**	
	Reference (Mt GHG)	**Isolated (Mt GHG)**	**Absolute (Mt GHG)**	**Relative (%)**
Paddy rice	0,50	0,37	-0,13	0,73
Wheat	2,28	1,36	-0,91	0,60
Cereal grains nec	1,91	1,40	-0,51	0,73
Vegetables, fruit, nuts	2,25	1,54	-0,71	0,68
Oil seeds	2,12	1,16	-0,96	0,55
Sugar cane, sugar beet	0,31	0,21	-0,10	0,68
Plant-based fibers	1,14	0,84	-0,30	0,74
Crops nec	1,06	0,90	-0,15	0,85
Bovine cattle, sheep, goats, horses	0,48	0,36	-0,12	0,75
Animal products nec	0,94	0,62	-0,32	0,66
Raw milk	0,31	0,25	-0,06	0,80
Wool, silk-worm cocoons	0,24	0,16	-0,08	0,66
Forestry	0,71	0,63	-0,08	0,89
Fishing	2,13	2,39	0,26	1,12
Coal	4,19	5,55	1,36	1,32
Oil	6,43	7,73	1,30	1,20
Gas	4,93	9,05	4,12	1,84
Minerals nec	4,43	8,22	3,79	1,86
Bovine meat products	0,34	0,59	0,25	1,74
Meat products nec	0,31	0,52	0,21	1,67
Vegetable oils and fats	2,25	3,05	0,80	1,36
Dairy products	0,73	1,03	0,30	1,41
Processed rice	1,01	0,71	-0,30	0,71
Sugar	0,64	1,10	0,46	1,71
Food products nec	3,43	4,28	0,86	1,25
Beverages and tobacco products	1,02	2,48	1,45	2,42
Textiles	8,07	6,27	-1,79	0,78
Wearing apparel	1,19	5,07	3,88	4,25
Leather products	0,72	1,21	0,48	1,67
Wood products	0,79	1,13	0,34	1,43
Paper products, publishing	7,21	12,46	5,25	1,73
Petroleum, coal products	27,02	52,58	25,56	1,95
Chemical, rubber, plastic	54,45	113,13	58,68	2,08
Mineral products nec	24,17	35,61	11,44	1,47
Ferrous metals	42,11	73,36	31,25	1,74
Metals nec	10,12	15,01	4,89	1,48
Metal products	2,54	4,84	2,30	1,91
Motor vehicles and parts	1,76	7,19	5,43	4,09
Transport equipment nec	2,26	4,58	2,32	2,02

Electronic equipment	3,59	14,29	10,71	3,98
Machinery and equipment nec	9,84	36,61	26,77	3,72
Manufactures nec	2,76	11,07	8,32	4,02
Electricity	311,97	473,48	161,51	1,52
Gas manufacture, distribution	4,74	8,55	3,81	1,80
Water	0,58	1,06	0,48	1,83
Construction	0,57	0,96	0,39	1,67
Trade	6,80	10,95	4,15	1,61
Transport nec	68,71	88,52	19,81	1,29
Water transport	11,21	19,48	8,28	1,74
Air transport	37,53	43,39	5,86	1,16
Communication	0,47	1,23	0,77	2,65
Financial services nec	0,75	1,18	0,43	1,57
Insurance	0,22	0,32	0,09	1,41
Business services nec	4,09	5,22	1,13	1,28
Recreational and other services	1,64	3,06	1,42	1,87
Public Administration, Defense, Education, Health	2,91	4,29	1,38	1,47
Dwellings	0,00	0,00	0,00	1,50

nec: not elsewhere classified