CO2 emissions embodied in trade

Analysis and policy implications

HIGHLIGHTS

- *International trade represents almost a third of World GDP; as such it is a major contributor of GHG emissions;*
- *GHG intensity of production differs significantly among countries: The same unit of product can embed six times more GHG emissions according to where it is produced;*
- *More carbon-intensive countries tend to specialize in carbon-intensive export sectors, suggesting that an increase in trade tends to increase global emissions;*
- *There is a major trade of GHG emissions from a bunch of producing countries in the developing World to consuming countries in the developed World;*
- *The largest flow of GHG emission is from China to North America: 553 million tons of CO2e are transferred through trade.*

POLICY AND STRATEGIC IMPLICATIONS

- *GHG mitigation policies must address the issue of international trade;*
- *This does not imply specific trade policies, but rather globally coordinated measures;*
- *Any international agreement on abatement measures should foresee massive technological transfer from advanced countries to developing economies;*
- *Without technological transfer, industrial activities might move back to mature economies, impoverishing the emerging world and generating dramatic distributive effects*
- *If a global agreement is not feasible, then a coalition of green countries can enact specific Border Carbon Adjustments (BCAs) measures, requiring importers to pay a charge according to the GHG content of the goods;*
- *Effective BCA measures should be able to address underlying causes of emissions intensity by spreading the costs of emission reductions, rather than just punishing emitters;*

Background[1]

International trade is a major pillar of the globalized economy: trade represents almost a third of World GDP, doubling its weight in less than 30 years. At the same time, an increasing number of products (Hanson, 2015) and tasks (Head and Mayer, 2015) are offshored. There is a global consensus that trade enhances economic growth and standard of living. Access to global markets is crucial for developing and least developed countries (Fontagné and Fauré, 2016, Docquier et al., 2016).

However there is also a growing consensus on the fact that, at present, trade may affect GHG emissions through three effects:

1. A scale effect
2. A technique effect
3. A Composition effect

Increasing trade leads to greater economic activity, meaning that more goods will be produced and, hence, more emissions will be produced. This first effect is called the "scale effect".

Moreover, as scientific evidence suggests, traded goods tend to have higher emission-intensities compared to average final demand; moreover, independently of sector structure, dirty exporting countries tend to specialize in emission-intensive sectors. On the other hand, clean countries tend to specialize in low-carbon technologies and in low-carbon goods. This second effect is called the "technique effect".

[1] This policy brief has been prepared by Federico Pontoni, within the Value Added in Motion (VAM) project, funded by the Enel Foundation

Finally, within a single Country, trade activity may also change the relative balance of activity in different sectors, resulting in an increase or in a decrease of country's emissions. This third effect is called the "composition effect".

While the scale effect has unequivocal negative impact on emissions, the impact of the other two effects on GHG emissions cannot be known a priori. In theory, they can both reduce emissions and they could also offset the increase brought about by the scale effect[2].

Several policy options exist to address emissions embodied in trade. As we shall see below, the nature of such policies, and particularly if they are set within a common global framework or through Border Carbon Adjustments of smaller coalition of countries, has considerable implications for future trade flows and industrial development. In this policy brief we discuss what type of policies can be implemented and whether they are desirable.

GHG intensity of production

The GHG intensity of production indicates the GHG emissions released in producing a unit of a given product. That same unit can have different intensities according, for instance, to the technology that has been used. There are several factors influencing GHG intensity, including:

- Technologies and processes used, such as the balance of labour versus technology used to make a product;
- Efficiency of operation of those technologies and processes;
- GHG intensity of the energy sector and the energy used to produce that product;
- GHG intensity of feedstocks, including all the above factors for the production of feedstocks and/ or component parts;
- Transportation distances and modes.

The above-mentioned factors are either company specific or Country-specific; hence, GHG intensity of a product is affected both at micro level and at macro level.

Up to day, there is no comprehensive review of the GHG intensity of production of a representative basket of product. Still, enough information is available to compare average emissions intensity of production for some goods and materials.

A recent study from the Stockholm Environmental Institute (SEI)[3] has assessed and summarized some of these different intensities.

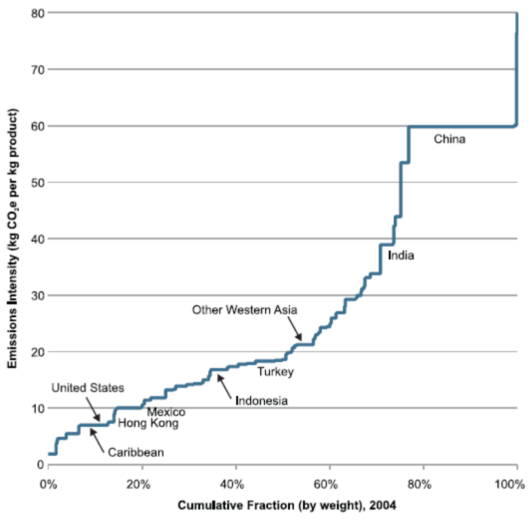


Figure 1: Estimated average GHG intensity of clothing production, by country, 2004.

[2] Tamiotti, L., (2009), Trade and climate change: a report by the United Nations Environment Programme and the World Trade Organization, United Nations Environment Programme and World Trade Organization, WTO Publications, Geneva.

[3] Erickson, P., Van Asselt, H., Kemp-Benedict, E., Lazarus, M., (2013), International Trade and Global Greenhouse Gas Emissions: Could Shifting the Location of Production Bring GHG benefits?, Stockholm Environment Institute, Project Report 2013-02.

Figure 1 presents emissions intensities in terms of CO2e per kilogram of clothing production. Clearly, the quality and, hence the value, of different clothes can vary significantly; still, international comparisons on GHG intensity can be more easily made in terms of quantity of clothes produced, rather than on quality of clothes produced.

Figure 1 shows that GHG intensity in some Countries can be eightfold than emissions in best performing countries.

This simple example confirms that Countries do not just differ for the different productions in which they specialize, but also for the different GHG intensity of their factors of production for the realization of the same product.

At the same time, focusing too much on production (in terms of both products and factors) can be misleading.

Who should be made accountable for GHG emissions? The producer or the consumer?

Whose emissions?

Production based GHG emissions

The standard approach to emissions assigns each country the quantity of GHG emitted due to the overall economic and production activities carried out within its borders. The approach is simple and effective, it guarantees longer time-series and, at least for developed economies, updated figures.

The table below shows the first ten emitting countries, according to the production-based approach[4].

Table 1: GHG Emissions for the ten most emitting countries according to the production-based approach. Source: OECD.

Country	**2009 GHG emissions (Million tons of CO2e)**
China	6,800.8
United States	5,184.8
India	1,564
Russian Federation	1,520.3
Japan	1,095.7
Germany	747
Canada	525.5
Korea	515.4
United Kingdom	465.5
Saudi Arabia	411.4

[4] We use the OECD database. The last available data also for production-based emissions is 2009 due to conformity and comparability of data.

The data are self-explaining. On the one hand, China and the US alone emit as the subsequent 32 Countries summed together. On the other, four countries (China, India, Russia and Saudi Arabia) are not OECD countries and four Countries (China, India, Korea and Saudi Arabia) never committed to reduce their emission prior to the COP21 agreement.

At the same time, four countries in the list are the first net exporters of traded goods (Germany, China, Russia and Saudi Arabia); Korea ranks among the top thirty and Japan is a net exporter as well, if we exclude energy products. On the other hand, the US and the UK are the top net importer in the global ranking[5].

Consumer based GHG emissions

The rationale

As stated above, trade extraordinarily increased in the last thirty years. This implies that there is a looser correlation between the products produced in one country and the products consumed in that same country (Wang, Wei, Yu and Zhu, 2015). In particular, in these last thirty years, developed economies have shifted their production to more value-added products and to services: therefore, it is likely that production patterns

[5] WTO statistics on world trade.

and consumption patterns have (slightly) diverged.

Therefore, there is the possibility that the reduction in GHG emissions achieved by one country does not imply that it has improved its emission efficiency, but rather that it is now importing goods that it was once producing.

Therefore, a more equitable way of measuring emissions is to compute those embedded in consumption: that is, in the end, final consumers are those responsible for GHG emissions.

This approach, despite being more accountable, requires more effort in providing reliable data, it is subject to a consistent time lag, and it explains why the data shown in this policy brief are not up to date.

First of all, in order to estimate the emissions embedded in consumption, there is the need to estimate the embedded emissions in trade; then, they have to be allocated to the products consumed within each country.

Trade and emissions

There are two prevailing methods for quantifying emissions associated with trade[6]. The first method, attributes emissions to individual trade flows between pairs of countries or regions, regardless of whether the good or material is a final or an intermediate product. This method has been termed emissions embodied in bilateral trade in the literature, or "EEBT". The second method attributes all emissions to final products purchased by consumers, and includes all the emissions associated (including for intermediate goods) to a given product, regardless where they are released. The second method relies on multiregional input-output modelling, and so has been termed the "MRIO" approach.

We provide a simple example to highlight the differences: a car made in Japan, using Chinese steel, and sold in the United States. The EEBT method attributes the emissions in Japan to trade of cars with the U.S., and the emissions in China, to trade of steel with Japan. Under the MRIO method, all the emissions would be attributed to imports of cars into the U.S.

From the example, it is clear that only the second method is applicable to the consumption-based approach.

Main data

In the table below, we show the first ten emitting countries, according to the consumption-based approach.

Comparing table 1 and table 2 provides useful insights. First China and the USA remain the top two emitting countries, but their gap reduces significantly. Almost 1,000 million tons of CO2e are emitted not for Chinese consumers but for the global demand.

Moreover, Korea and Saudi Arabia disappear from the list and are substituted by Italy and France.

More in general, the consumption-based methodology increases the quantity of emissions attributable to developed countries while reducing considerably the emissions attributable to developing countries.

Table 2: GHG Emissions for the ten most emitting countries according to the consumption-based approach. Source: OECD.

Country	**2009 GHG emissions (Million tons of CO2e)**
China	5,835.7
United States	5,685.2
India	1,505.8
Japan	1,228.6
Russian Federation	1,067.9

[6] Peters G. P, J. Minx, C. Weber, and O Edenhofer (2011), "Growth in emission transfers via international trade from 1990 to 2008 ", Proceedings of the National Academy of Sciences, 108(21), 8903-8908.

Germany	865.5
United Kingdom	594.6
Canada	543.1
Italy	524.9
France	499.7

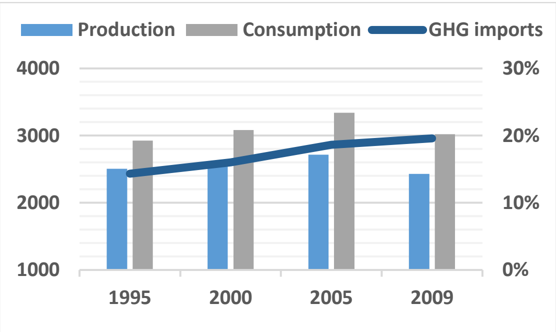
GHG imports and exports

The comparison between the two tables show unequivocally that there is a significant "trade" of GHG emissions from a bunch of producing countries in the developing World to consuming countries in the developed World.

The four largest interregional flows are from China to North America (553 Mt CO2e), China to Europe (488 Mt CO2e), Other Asia to Europe (347 Mt CO2e), and Other Asia to North America (290 Mt CO2e). North America, Europe and Japan all have considerably more emissions associated with imports than with exports.

Figure 2 shows the difference between production-based emissions and consumption-based emissions in the EU.

Figure 2: Evolution of Production based and consumption based emissions for the EU.



As it is possible to notice, in 2009 production-based emissions were lower than those in 1995 (a 3.1% reduction). At the same time though, the consumption-based approach reveals that emissions grew by 3.3% in the same period. Therefore, GHG imports have increased by 41% and now they represent 20% of the overall GHG emissions embedded in our consumption.

The effects of trade on the economic structure

More carbon-intensive countries tend to specialize in carbon-intensive export sectors, suggesting that an increase in trade tends to increase global emissions.

Moreover, as claimed in the paper by Weber et al. (2016), more trade-exposed sectors are more emissions intensive than sheltered sectors. Therefore, increasing trade is likely to further increase the emission-intensity of traded goods. This is the case for coal-rich countries, which have a tendency to specialize in 'dirty' sectors. Many of these countries are also developing economies. As their income grows, their emission intensity tends to decline, but insufficiently to reduce overall emissions. [7]

Thus, on the one hand, the available empirical evidence – including Galeotti at el. (2015) – confirms that scale effects dominate in developing countries. On the other hand, the empirical evidence also shows that North America, Europe and Japan have had positive technique and composition effect (Levinson, 2015). Globally, though, the total effect is an increase in emissions – at least until 2015.

These findings highlight the importance of considering trade, and paying due attention to fossil fuel markets, specifically coal, when designing CO_2 reduction strategies.

Trade policies: is this the right way?

In the future, effective GHG mitigation policies must address the issue of international trade. As seen, global emissions are not reduced when countries export their emissions outside of a regulatory zone. Moreover, it is not

[7] Weber, S., Gerlagh, R., Mathys, N.A., Moran, D., (2016), CO_2 embedded in trade: trends and fossil fuel drivers, Enel Foundation Working Paper Series, forthcoming.

desirable that domestic abatement policies are undermined by carbon-intensive imports.

The question is whether more effective domestic abatement policies are enough to curb emissions at a global level, or instead, there is the need to implement specific trade policies to steer trade flows and, by extension, production, to world regions with low GHG intensity.

If the bulk of emitting countries start serious, coordinated and effective policies of emission reduction, then trade policies would be redundant and counter-effective.

On the other hand, trade policies targeting GHG emissions might be an initial step to force all countries to cooperate and enact abatement programs.

Possible policies

Apart from standard trade policies[8], countries willing to tackle trade related emissions could introduce specific Border Carbon Adjustments (BCAs) measures. There are two broad design options:

- Border Tax Adjustments (BTAs);
- The requirement for importers to surrender allowances at the border.

A BTA requires importers to pay a charge equivalent to a tax applied to goods produced domestically, whereas a requirement to surrender allowances is linked to an emissions trading scheme (ETS), and permits goods to enter a country only if a certain amount of emission allowances are purchased that reflect the GHGs emitted during production[9].

The environmental effectiveness of both policies rests on their design. Taxing the carbon content of a good is not an easy task, because several assumptions have to be made.

This, in turns, makes the legal feasibility a question mark, as tax laws require the easy and unequivocal determination of the tax base: only an international and shared methodology of carbon accounting would stand any legal challenge.

This final point implies that there is the need to have a political support from a consistent group of countries. Any BCA policy cannot be implemented unilaterally: a coalition of “green countries” is required.

The effect of internationally agreed climate change policies

As discussed in the VAM final report, all developing economies that have managed to kick start an effective process of industrialisation have initially exploited old-style comparative advantages: low value added and highly polluting industries and disruptive mass migration and urbanization. The division of labour among emerging and developed countries will continue to reflect this pattern, unless there is a clear change in global environmental policy, which is hopefully likely to emerge.

These internationally agreed climate change policies would foster rapid transition towards more stringent environmental standards, technological upgrading and a rising demand of skilled labour in developing economies; still, mature economies will likely preserve a lead in quality.

Of course, It is not sure whether developing countries will manage to easily move up through this path of technological transition. South Korea has certainly managed; today it has achieved higher levels of average

[8] A comprehensive review can be found in: Pauwelyn, J. (2013). The end of differential treatment for developing countries? Lessons from the trade and climate change regimes. Review of European, Comparative and International Environmental Law, 22(1).

[9] Van Asselt, H. and Brewer, T. (2010). Addressing competitiveness and leakage concerns in climate policy: An analysis of border adjustment measures in the US and the EU. *Energy Policy*, 38(1). 42–51.

industrial productivity than the US. China is still lagging behind and it is not at all obvious that the transition will be smooth.

Anyway, the easy avenue of cheap, low skill polluting industry is reaching an end. The global division of labour we have observed up to now, will probably no longer be viable and sustainable. Other global equilibria will have to emerge.

Actually, things get more complex as countries move up the technological ladder. The adoption and diffusion of clean technologies in more advanced industries requires the involvement of skilled personnel, and the investment costs will force developing countries away from low value added activities.

Hence, an important element of this new global environmental framework requires massive cooperation from advanced countries.

For instance, the challenge for any globally coordinated policy is to ensure that countries that specialize in pollution intensive exports (such as aluminium and steel) do so with the best available clean technology, rather than just being punitive.

In this regard, these policies should somehow recycle their revenues back to developing exporting countries, in order to provide them with the financial means to adopt and implement low carbon technologies and improve their emission efficiency.

Without any form of technological transfer, an alternative possible outcome is that industrial activities will move back to mature economies, where the skills and technologies for clean and high value added industry are readily available. As stated in the VAN policy paper, this is not a desirable outcome as it implies an impoverishment of the emerging world and dramatic distributive effects. The option of having a clean world at the expense of the development of poor countries is also unsustainable.

Final considerations

In the end, any trade policy aimed at curbing emissions has to be designed so that it addresses the underlying reasons for emissions embodied in trade (e.g. high levels of consumption in importing countries or lower levels of financial and technological capacity in exporting countries). This implies an international agreement on climate change policies.

Otherwise, standard trade policies would end up just reducing or shifting trade, undermining sustainable growth and harshening relations among countries.

Further readings

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