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ENVIRONMENTAL IMPACTS OF GLOBAL SUPPLY CHAIN: A REVIEW OF SCIENTIFIC , POLICY AND LEGAL COMPONENTS FOR INCLUDING ENVIRONMENTAL AND CLIMATE CHALLENGES

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Executive summary

During the last two decades globalisation has been a key variable driving economic growth and raising the living standards of nearly everyone on the planet, although not without cost. Indeed, the growth in world trade and capital flows resulting from globalisation is now increasingly seen as an issue in the scientific and political debate on the environmental impacts of global supply chain and consumption. Most cost efficient locations around the world accelerate the trends towards international specialization causing some distortions of the markets in terms of the use of natural resources. The relative international competitiveness of companies in nations with stronger environmental protection regulations (haven hypothesis) is one argument for looking at alternative global environmental regulatory tools that are compatible with international trade agreements and development policies. However, trade is not a driver of environmental degradation, but the structure of the markets and the presence of market failures (externalities, no definitions of property rights) are the causes of environmental degradations.This report introduces the key features of global supply chain and its environmental impacts related to biodiversity loss, water conservation, raw material.

The report provides a deep analysis on Climate change and global supply chain. It analyses the scientific, legal and policy components of the international debate over carbon and trade. It introduces and analyses the concept of the consumption-based approach and compares it with the production-based one. Then, Border Adjustments (BA) are discussed in relation to their impact on competitiveness and potential for carbon leakage. The legal implications of introducing BA within the WTO framework are described. The report highlights that policy makers should look beyond the traditional geo-political regions and a consumption-based perspective would represent a significant step in this direction in order to manage a sustainable global supply chain.

1. Introduction

During the last two decades globalisation has been a key variable driving economic growth and raising the living standards of nearly everyone on the planet, although not without cost. Indeed, the growth in world trade resulting from globalisation is now increasingly seen as an issue in the scientific and political debate on the environmental pressures of global supply chain and consumption patterns. The international debate concerns two main aspects: (i) sustainable management of natural resources and international trade in natural resources and (ii) existence of market failures.

Economic theory states that country more open to the trade can improve the aggregate level of income, wealth and welfare. This concept is the theoretical basis of the current globalization patterns which manifests its possible positive effects mainly in two ways: (1) increase level of income due to more efficient allocation of its production factors (labor, capital and land) with a geographical concentration of industries through increased specialization; (2) higher returns to investments; technological spill overs.

Regarding the natural resources and trade according with WTO (2010) "natural resources can be defined as "stock of materials that exist in the natural environment that are both scarce and economically useful in production or consumption, either in their raw state or after a minimal amount of processing". In general terms natural resources involved within the global trade flows are the "sum of forestry products, fish, fuels and mining products" (WTO, 2010).

In the recent decades there has been a expansion of the volume and range of natural resources traded internationally transforming the market of the commodities and the structure of global economy (WTO,2010). The price of primary commodities (excluding the high volatility of the fuel price) has continued to decline over the time relative to the price of manufactured good contributing to an increasing use of natural resources. Other key factors of the increasing international trade of natural resources are population growth; spreading industrialization; technology advance in transportation with a decreasing transport costs since the 19th century,

and from the 1980s the creation of an opening global commodity markets and reductions of tariff barriers.

However, the paradigm reducing trade to reduce globalization and environmental degradation is not right. Trade is based on comparative advantages. Studies analyzing cross section of countries find little evidence to support the view that patterns of trade are determined by differences in environmental regulations (Mac Dermott et all, 2010). Trade can lead to specialization in a country with lax environmental standards. Increased trade may increase the incentive to export hazardous waste to the countries least able to deal with this issue. However, the problem of environmental degradation are mainly related to the market structure and property rights.

Moreover, Due to uneven distribution the gains from trade of natural resources are for countries rich of natural resources on the basis of comparative advantages.Analyzing the world merchandise trade statistics data, we can notice that natural resources sector is the dominant one in many national economies such as Angola, Venezuela, Sudan, Congo and Nigeria. The sector is characterized by leading exporters and importers and European Union as a single trader can be considered the largest single market for natural resources.

Key issues for the natural resources and trade are the exhaustibility and externalities. Exhaustibility regards mainly the efficiency of extraction and optimal extraction rates .

Population growth and exhaustibility of natural resources is a key issue of the scientific debate starting from Malthus till the Limit to growth of the Club's Rome 1972. It is also a not solved problem. Core aspect of such debate is the possibility of perfect substitution of natural capital and human made capital (technological innovation). In 1992, Nordhaus in his publication "Beyond the limits " criticizes the conclusion of the Rome's Club stating: "Our estimates are crude, the models are primitive, the future is uncertain and our ignorance is vast".

Scarcity is considered as a motor to stimulate investments in new technologies and innovations looking for alternative resources and solutions. Moreover, Solow in 1974 argues that" exhaustion is just an event , not a catastrophe".

Some factors may accelerate resource consumption compared with social optimum and exacerbating the negative impact on the environment. For instance, in the case of open access (such as for fish) poor defined property rights lead to rapid depletion. Establishing individual property rights and trade and environmental issues are often connected.
Externality is a key concept of the environmental economics and it is related to the extraction and use of natural resources and they are due to the presence of market failures.

This report analyses the key features related to global supply chain and its environmentalimpacts related to biodiversity loss, water conservation, raw material.
The report provides a deep analysis on Climate change and global supply chain. This report analyses the scientific, legal and policy components of the international debate over carbon and trade. It introduces and analyses the concept of the consumption-based approach and compares it with the production-based one. Then, Border Adjustments (BA) are discussed in relation to their impact on competitiveness and potential for carbon leakage. The legal implications of introducing BA within the WTO framework are described. The report highlights that policy makers should look beyond the traditional geo-political regions and a consumption-based perspective would represent a significant step in this direction in order to manage a sustainable global supply chain

2. Biodiversity

International trade of commodities can cause biodiversity loss. The entire analysis of supply global chain connecting economic activities to final consumption highlights this issue. Lezen et al (2012) investigate this connection using a multiregional I-O model linking economic activity to biodiversity. Lezen et al (2012) estimates that 30% of biodiversity loss for the reed listed species worldwide are due to international traded commodities and USA, Japan and EU countries are net imports of species. In the figure below an example of such estimation shows

the low map of threats to species caused by exports from Malaysia (reds) and imports into Germany (blues).

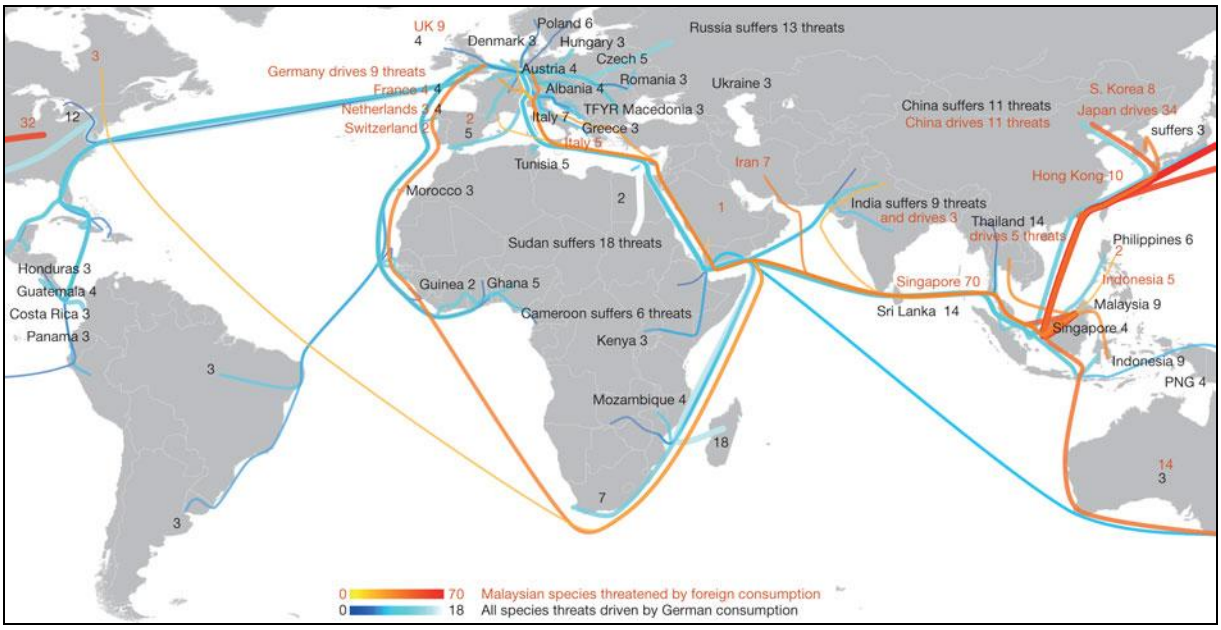

Figure 1: low map of threats to species caused by exports from Malaysia (reds) and imports into Germany (blues).M. Lenzen *et al. Nature* 486, 109-112 (2012) doi:10.1038/nature11145

3. Water

As pointed out, natural resources are trade relevant if they are scarce and useful in consumption and production in their raw state or after a minimal amount of processing (WTO, 2010).Water is not a commodity and is not directly traded but it is unevenly distributed across countries. However, trade of water intensive products from regions of water abundance to regions where the water is scarce can generate water saving in importing countries and environmental impacts for water conservation.

Wichelns (2004) defines the theory of virtual water trade applying the Ricardo's theory of comparative advantages to the international trade and water availability. The table below gives an example of nations with net water saving as a result of international trade in agriculture products.

Country	Total use of domestic water resources in the agricultural sector[1] (10^9 m^3/yr)	Water saving as a result of import of agricultural products[2] (10^9 m^3/yr)	Water loss as a result of export of agricultural products[2] (10^9 m^3/yr)	Net water saving due to trade in agricultural products[2] (10^9 m^3/yr)	Ratio of net water saving to use of domestic water (per cent)
China	733	79	23	56	8
Mexico	94	83	18	65	69
Morocco	37	29	1.6	27	73
Italy	50	87	28	59	98
Algeria	23	46	0.5	45	196
Japan	21	96	1.9	94	448

Table 1: Example of nations with net water saving as a result of international trade in agriculture products, 1997 – 2001 (WTO, 2010: p. 75)

The figure below shows Virtual water balance per country and direction of gross virtual water flows related to trade in agricultural and industrial products over the period 1996–2005. Only the biggest gross flows (>15 Gm3_y) are shown. (Hoekstra, Mekonnen, 2012)

The trade in virtual water can have a negative impact on water conservation in particular when there is an artificial low pricing system.

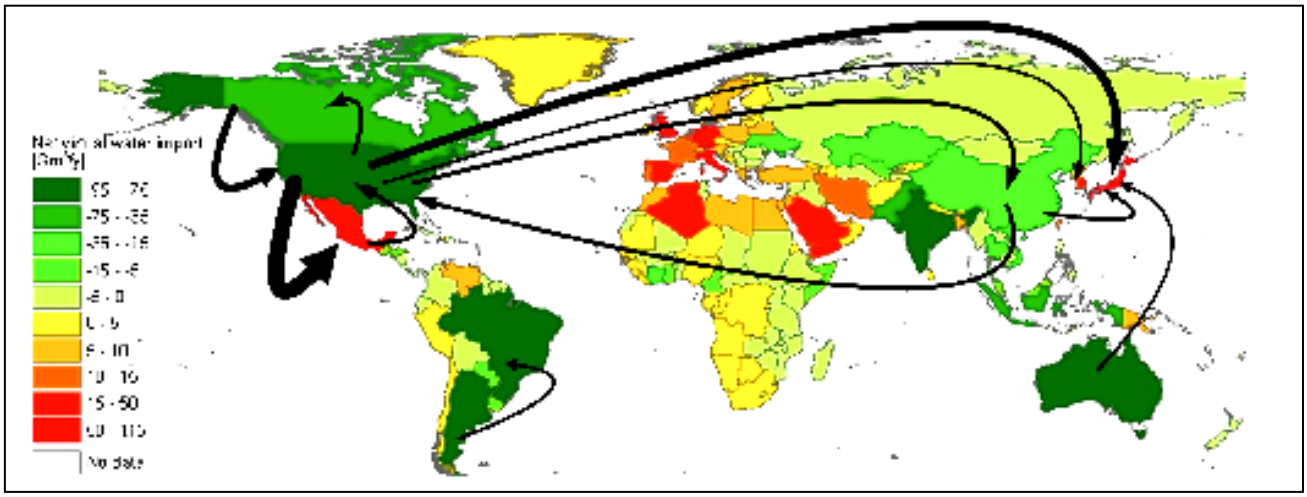

Figure 2: Virtual water balance per country and direction of gross virtual water flows related to trade in agricultural and industrial products over the period 1996–2005. Only the biggest gross flows (>15 Gm3_y) are shown. (Hoekstra, Mekonnen, 2012; p. 4).

In Hoekstra and Mekonnen, (2012) the total volume of international virtual water flows related to trade in agricultural and industrial products was estimated in 2,320 Gm3/y (68% green, 13% blue, 19% gray). The authors calculate the water footprint of the global average consumer that was 1,385 m3/y.

The average consumer among the countries is very different for instance in the United States the water footprint is estimated of 2,842 m3/y, whereas the average citizens in China and India have water footprints of 1,071 and 1,089 m3/y, respectively.

4. Raw Material

The international trade of raw materials is a more and more relevant issue within the context of economic growth and globalization. It has been a core aspect of the international trade since the first industrialized era.

Dittrich et al (2012) analyse the performance of different countries in terms of patterns of material extraction, consumption and resources productivity from 1980-2008. They identify the current trend in resources use for the following materials: Biomass (from agriculture, forestry, fishery, and hutting); Minerals (industrial and construction minerals); Fossil energy Carriers (coal, oil, gas, peat); metal ores (ferrous and non ferrous metal).

The figure below summarizes the results with regard to the GDP, population and material use, estimating around 10 tonnes of material per capita in 2008 (1,6 tonnes more than 1980).

Since 2000 a stagnant material productivity is registered posing issues for the efficiency use of materials.

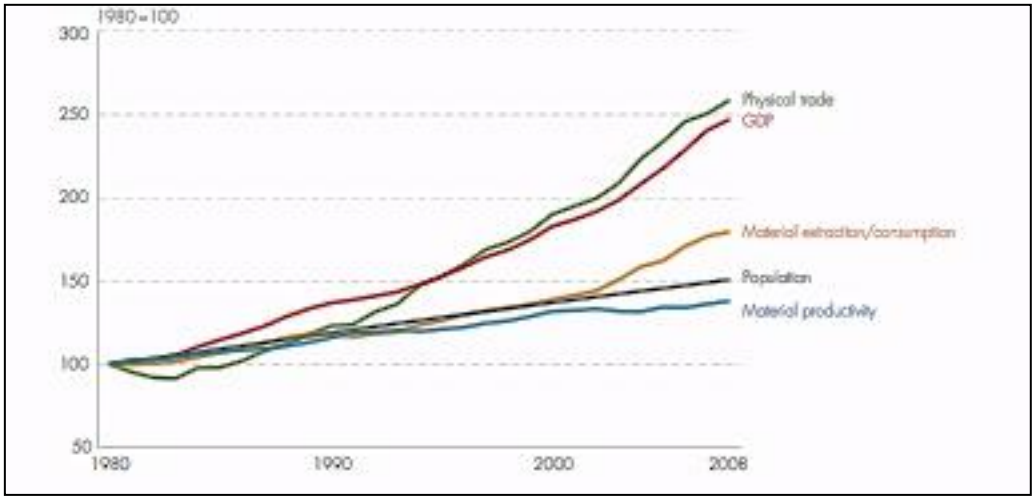

Figure 3: Global trends in resource extraction, GDP, population and material intensity in indexed form (1980 equals a value of 100).Dittrich et al (2012): p. 17

In terms of future trends Dittrich et al (2012) estimate that in a business as usual scenario in 2030 all the countries (industrialized and emerging countries) will have the same pro capite level of consumption of material aggravating the material scarcity. The figure below summarise such estimations where in 2050 the humans will require 180 tonnes of different materials with a growth factor of 2.7 compared to today's

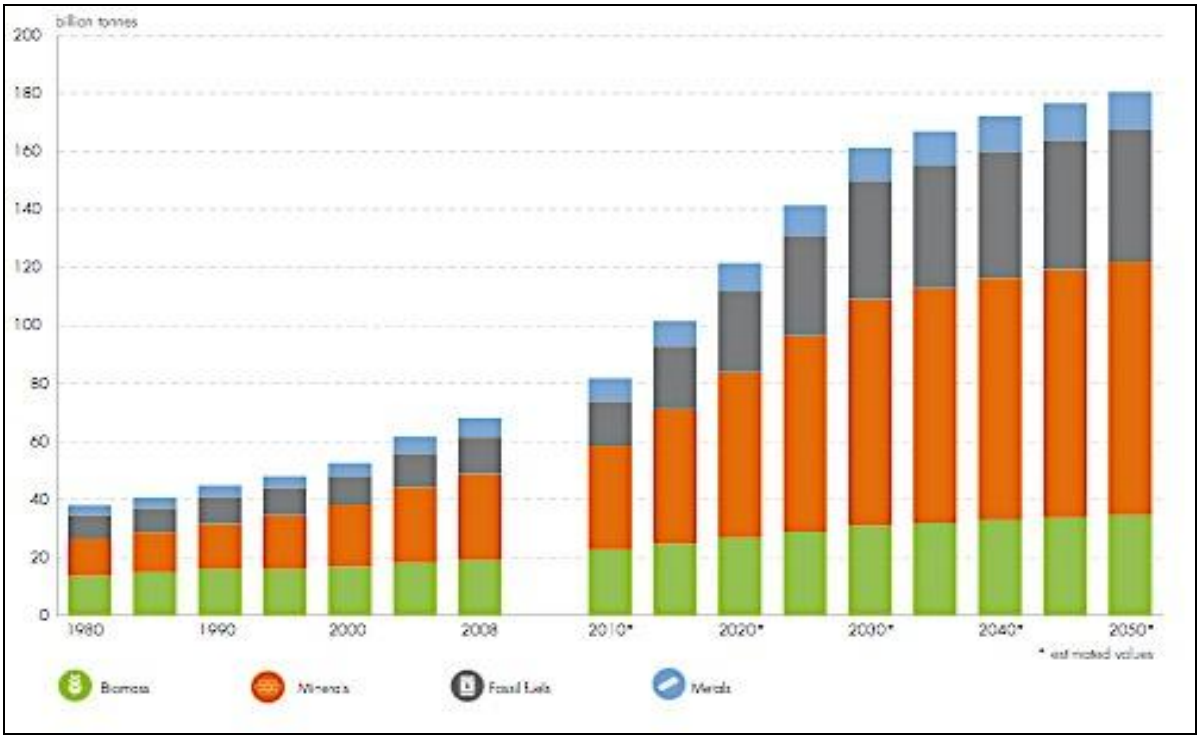

Figure 4 : Business as usual scenario in 2030 and 2050 all the countries (industrialized and emerging countries). Dittrich et al (2012) p. 64

As pointed out, the sustainable management of raw material is central for economic growth for industrialised, emerging and developing countries. Strategies for sustainable use of raw material are central issue of global trade agreements and economic policies. In Europe, the Resource-Efficient Europe, one of the seven flagship initiatives of the Europe 2020 strategy in support of sustainable development objectives, defines a framework for policies to support the shift towards a resource-efficient and low-carbon economy. In addition to this Strategy Raw materials are also the core issue of the European Trade policy. The EU Trade policy for Raw materials is defined by the Communications issued in 2008, 2010 and 2011 respectively: The

raw material Initiative – meeting our critical needs for growth and jobs in Europe COM(2008)699; "Trade, growth and world affairs –Trade policy as a core component of EU's 202 Strategy COM(2010) 612; Tackling the challenges in commodity markets and on raw materials COM(2011) 25 Final; Trade, Growth and development tailoring trade and investment policy for those countries most in need COM(2012) 22 final.

The EU trade policy for raw material is organized to achieve a sustainable supply of raw materials and it is organized on the basis of three key pillars:

1) Access to raw materials within a global markets which presents some distortions;
2) Internal sustainable supply from European resources;
3) Development of cooperation measures supporting sustainable development in supply countries.

The table below shows the main producers, main sources of imports into EU-27, import dependency rate, substitutability and recycling rate imports for 14 key raw materials whose demand is increasing due to their use for making cell phones, solar power cells, batteries and other electronics.

Table 2 Main producers, main sources of imports into EU-27, import dependency rate, substitutability and recycling rate imports for 14 key raw

Raw materials	Main producers (2008, 2009)	Main sources of imports into EU (2007, or 2006)	Import dependency rate	Substitutability	Recycling rate
Antimony	China 91%	Bolivia 77%	100%	0,64	11%
	Bolivia 2%	China 15%			
	Russia 2%	Peru 6%			
	South Africa 2%				
Beryllium	USA 85%	USA, Canada, China, Brazil (*)	100%		
	China 14%				
	Mozambique 1%				
Cobalt	DRC 41%	DRC 71%	100%	0,9	16%
	Canada 11%	Russia 19%			
	Zambia 9%	Tanzania 5%			
Fluorspar	China 59%	China 27%	69%	0,9	0%
	Mexico 18%	South Africa 25%			
	Mongolia 6%	Mexico 24%			
Gallium	NA	USA, Russia (*)	(*)	0,74	0%
Germanium	China 72%	China 72%	100%	0,8	0%
	Russia 4%	USA 19%			
	USA 3%	Hong Kong 7%			
Graphite	China 72%	China 75%	95%	0,5	0%
	India 13%	Brazil 8%			NA
	Brazil 7%	Madagascar 3%			
		Canada 3%			
Indium	China 58%	China 81%	100%	0,9	0,30%
	Japan 11%	Hong Kong 4%			
	Korea 9%	USA 4%			
	Canada 9%	Singapore 4%			
Magnesium	China 56%	China 82%	100%	0,82	14%
	Turkey 12%	Israel 9%			
	Russia 7%	Norway 3%			
		Russia 3%			
Niobium	Brazil 92%	Brazil 84%	100%	0,7	11%
	Canada 7%	Canada 16%			
Platinum group metals	South Africa 79%	South Africa 60%	100%	0,75	35%
	Russia 11%	Russia 32%			
	Zimbabwe 3%	Norway 4%			
Rare earths	China 97%	China 90%	100%	0,87	1%
	India 2%	Russia 9%			
	Brazil 1%	Kazakhstan 1%			
Tantalum	Australia 48%	China 46%	100%	0,4	4%
	Brazil 16%	Japan 40%			
	Rwanda 9%	Kazakhstan 14%			
	DRC 9%				
Tungsten	China 78% (6,1)	Russia 76%	73%	0,77	37%
	Russia 5% (6,5)	Bolivia 7%			
	Canada 4%	Ruanda 13%			

(*) subject to strong fluctuations

Source EC. Tackling the challenges in commodity markets and on raw materials COM(2011) 25 Final

Raw material use is a more and more important issue for the environmental and economic policies. On the one hand, the high rate of growth patterns of emerging countries requires an

increasing use of materials. On the other hand, climate polices based on clean technologies, as recognized by IPCCC(2007) will affect the use of resources. Steger and Bleischwitz (2011) identify the drivers of such increasing material use on the basis of technological progress; structural change (such as the demand of new goods); saturation of infrastructure investments and new lifestyle for green markets. Steger and Bleischwitz (2011) recognize that stringent environmental polices can force pollution intensive sectors to move to regions more favorable if the abatement costs are too high.

5. Global supply chain and climate change

As international climate change agreements are characterized by agreeing on 'common but differentiated responsibilities' and Annex I countries are introducing more stringent environmental regulations, competitiveness concerns of companies under regulation become more significant. The international policy debate reflects the need to address these concerns by introducing border adjustments (BA) as a means to offset the side-effects of domestic environmental rules. Since 2007, various climate bills proposed in the US Congress have included a BA option, as does the latest Waxman/Markey bill that also introduces output-based rebates. An amendment states that if these rebates are insufficient to address competitiveness concerns, BA measures will be adopted by 2020 unless both Congress and the President agree that it is not in US national interest (Dröge, 2009). The EU ETS Directive, which was revised in 2009, addresses carbon leakage concerns by including importers of products from heavily-polluting sectors in the scheme, which can be regarded as a BA measure (Kuik and Hofkes, 2009). BA based on the carbon contents of imported goods intensifies incentives for greener production and consumption internationally. However, in the literature it is highlighted that environmental border policies place an unequal burden on exporting countries due to a high variation in carbon intensity of exports. As Atkinson et al (2010) show for example, a border tax on CO_2 would result in substantial effective tariff rates on imports from most developing countries. It would create a situation where China faces average taxes of 10.3% on its exports to the US while the EU only faces 1.2% export taxes. Therefore, it is clear that the environmental

policy in question has to strike a balance between environmental effectiveness and equity concerns.

Besides the design of the BA policy, also the carbon emissions embodied in the products can vary under different accounting methods. In recent literature it has been advocated to shift from the current production-based quantification of CO_2 emissions to consumption-based quantification in order to promote the design of a more equitable, effective and participatory future climate policy (see Atkinson et al, 2010; Helm et al, 2007; Munksgaard et al, 2009; Peters and Hertwich, 2008a). With production-based CO_2 emission quantification, the relative pollution is allocated to the country where the goods are produced, and for which it is considered responsible in environmental regulations. As a result, this approach excludes the global emissions embodied in international trade. Moreover, it has the tendency to shift responsibilities as countries can virtually export their CO_2 emissions in order to comply with (inter)national climate change agreements. Consumption-based CO_2 quantification on the other hand does include emissions from international transport, as it allocates the total emissions based on the country where the goods are consumed. That emission inventories differ greatly between the two quantification methods can be illustrated by a finding of Helm et al (2007), that is, the UK's CO_2 emissions have declined by 15% since 1990 when using production-based measurement, while they have risen by 19% in the same period when using consumption-based measurement. In this paper we will make use of consumption-based CO_2 quantification where necessary, as it gives a more consistent and fair description of a country's environmental balance and it rightfully includes emissions from international transport.

Virtual carbon can be measured either using top-down or bottom-up methods. If the former, using input-output tables, is useful when it comes to country analysis, the latter is suitable for specific products. Embodied carbon assessment can incur some inconveniences, like data scarcity, calculation complexity (especially when it comes to long and complex production value chains), and cost and time requirements.

6. Consumption-based approach applied to input-output tables

The global effort to prevent additional anthropogenic interference with climate change calls for stabilization of greenhouse gas (GHG) concentration in the atmosphere (UN, 1992). Nations are asked to reduce the global amount of emitted GHG, thus, reverse past and current GHG emission trends. In the process towards setting the context to reduce the world's pressure on our ecosystem, an important debate concerns emissions accounting.

By switching from the production based approach to the consumption one, different emission allocations can be accounted for the same country (Eder & Narodoslawsky, 1999; Peters & Hertwich, 2007; Peters et al 2011). The aforementioned is a sensitive issue, because GHG inventory constitutes the basis not only for defining any commitment within any climate mitigation action either in Kyoto or Post-Kyoto age and evaluating if and where actual decrease is occurring, but also for affecting the countries' willingness to participate in the global climate effort.

The UNFCCC requires the Parties to record and compare GHG emission trends over time through National Emission Inventory (NEI). The approach adopted in UNFCCC's NEI is territorial-based (and producer responsibility). It encompasses emissions and removals within national onshore and offshore territories (IPCC, 1996). This approach uses a country's geographic definition and is founded on the idea that each country is responsible for emissions of its own production. It means that consumers and in turn the whole "importing country" benefitting from internationally traded goods, do not bear any responsibility for the carbon content of the products they consume. By not directly accounting for carbon in international trade and investment flows, such an approach may not only cause fairness issues, but may also distort the understanding of the real causes of carbon emissions, the climate policy to be adopted and where to intervene.

Major criticism stresses the fact that in a world with a sub-global climate regime such an accounting system leaves room not only for competitiveness concerns, but also for relocation

of production, and thus of emissions, to non-mitigating countries, namely carbon leakage[1] (Peters, 2008; Peters & Hertwich, 2008a; 2008b). Under a system that sets commitments on the basis of territory and production criteria, developing countries whose emissions are mostly associated with production for exports might feel particularly affected by it and their participation in the global mitigation effort might be even more discouraged. This approach entails another relevant drawback: its system boundary (geographic, within national territory) does not correspond with the one (economic, from resident institutional units) used in national economic accounts, i.e. System of National Accounts (UN, 1993), for example for GDP. Consequently, it is not possible to make any direct comparison between those data (Gravgård Pedersen & de Haan, 2006; Peters&Hertwich 2008a). Last but not least, we should bear in mind that the current approach is not allocating to any country all the emissions from international transportation of goods and services, probably because of both the complexity in assigning responsibilities and the lack of data (Olivier& Peters 1999).

The essential idea behind the consumption-based approach is that the overall carbon emissions "triggered by" a certain country are the ones occurring throughout the supply chain of the good and services consumed by that country.

Once the emissions of domestic production are determined, the consumption-based inventory might be calculated by both subtracting the emissions necessary to produce a country's exports and adding the emissions embodied in imports. Summing up, the formula to calculate the

[1]Carbon leakage can be defined as (IPCC, 2007 ; Peters& Hertwich, 2008a, 2008b):

- (Strong Definition by IPCC, 2007): increase in non-Annex-B emissions divided by the reduction in Annex B emissions. Its focus is on the production shift from Annex B to non-Annex B countries in response to mitigating policies. Little empirical evidence connecting strict environmental regulation and shift of production.
- (Weak Definition)Weak: total aggregated CO_2 flows from non-Annex B countries to Annex B countries. Its aim is to make evident how much production in non-Annex B countries is to meet Annex B's consumption. Usually literature deals with this second definition.

In a sub-global climate regime, carbon leakage occurs if (Peters& Hertwich, 2008b):

- companies in the mitigating country can close and migrate where environmental regulation are less strict (Strong Pollution Heaven Hypothesis)
- consumption in mitigating countries is met increasing production in non-mitigating countries (Weak Pollution Heaven Hypothesis)
-

emissions embodied in a country's consumption is: Consumption = Production – Exports + Imports (Peters & Hertwich, 2008a). By accepting such a definition, each country is accountable for emissions necessary to meet its demand, regardless of where the production takes place, either domestically or abroad. The discrepancy between territorial and consumption-based inventory is equivalently represented by what Peters et al. (2011) call emission transfer, which is the difference between emissions to produce the exports and those to produce imports. When the territorial emissions are adjusted for net emission transfers, a consumption based emission inventory is obtained.

Peters (2008) schematizes the procedure that leads from the territorial based to consumption-based inventories as follows (Peters, 2008):

Step 1: from technology-based to production-based inventory; thus, from UNFCCC inventory to an inventory that is consistent with System of National Accounts.

Step 2: from production-based (residential institutions) to consumption –based inventory, where the data from the former one are re-allocated following an Input-Output Analysis (IOA) (even though methods other than IOA are available).

7. Multiregional Input-Output model

How is it possible to measure the carbon embodied in trade flow or associated with consumption? The popular way to model the carbon embodiment of trade is the application of environmentally extended input-output analysis for multiple regions (MRIO) (Peters *et al.* 2011; Peters, 2008; 2007; Miller and Blair, 1985; 2009; Ahmad and Wyckoff, 2003; Lenzen et al., 2004; Peters & Hertwich, 2004; Turner et al.,…; Peters & Hertwich, 2006a, 2008b; Wiedmann et al, 2007, 2009, 2011; Wiedmann 2009; Zhou & Kojima, 2009; Zhou et al., 2011; Nakano et al. 2009). The MRIO model links together national input-output tables, which show the financial transactions between economic sectors within a country, and trade flow tables, which show the value of exports and imports by country and sector. This inter-industry matrix is further improved by adding links to primary inputs and final demand. The environmental extension can be achieved by adding inputs and factors of production to the framework.

Single-Region Input-Output approach (SRIO) has been largely used as well. It assumes that the same technology is employed domestically and abroad for producing goods and services in each of the sectors (for a complete overview, see Wiedmann et al, 2007; Wiedmann 2009). But MRIO overcomes some of the limitations of SRIO, in the sense that it makes clear the difference in technologies and resource and pollution intensities of several sectors in the different countries. The starting point of such analysis is always the same: the traditional input-output (IO) analysis (Leontief, 1970)[2]. It determines first the economic output, then its environmental impacts. To further model the emissions embodied in trade, the standard IO model is decomposed into the final use of domestically produced and imported products (Peters & Hertwich, 2004; 2006; Peters, 2007).

Two different approaches are available to model the emissions embodied in trade (Peters 2008, 2007).Emissions Embodied in Trade(EET) and Emissions Embodied in Consumption (EEC). EET approachuses bilateral trade statistics. It does not split bilateral trade flow into final and intermediate consumption of goods. This method looks at the total imports and exports of a country not making any distinction on their allocation to either final demand or industry. EEC approach is helpful when there is a necessity to know the amount of emissions to produce certain products. It points out if trade serves intermediate consumption or instead final consumption. The distinction between EET and EEC lies in the fact that imports may pass-through a certain economy and be allocated? to production of exports, not to final demand.
In order to summarize and make clear the distinction among the different approaches, an example from Peters *et al.* (2011) is given, on emissions produced by the German transportation sector. The fuel used in Germany is extracted in Norway and refined in the Netherlands. The accounting scheme is the following:

[2]The International Input-Output Association (IIOA) initiated by an informal world-wide network of economists, government officials, engineers and managers, works for the advancement of knowledge in the field of input-output analysis More information can be retrieved from: http://www.iioa.org/. The IIOA joint research is steered by the yearly IIOA Conference. The amount of works admitted to the IIOA annual Conferences represents an extensive tank of updated knowledge on Input-Output analysis. A complete database on peer-reviewed articles accepted at the 19th IIOA Conference in Alexandria is available at: http://www.iioa.org/Conference/19th-downable%20paper.htm

- **production-based** approach: Germany accounts for emissions from transport, Norway for emissions from extractions and the Netherlands for emissions from refining;
- **consumption-based** approach – *EET (Emissions Embodied in Trade)*: Germany accounts for emissions from transport and for emissions for refining, while the Netherlands accounts for emissions from extraction. Norway accounts for no emissions
- **consumption-based** approach – *EEC (Emissions Embodied in Consumption)*: Germany accounts for emissions from transport, for emissions for refining and for emissions from extraction while the Netherlands and Norway account for no emissions.

Choosing EET or EEC methodology depends on the interest on aggregated trade or arbitrary consumption. As Munksgaard et al. (2005) claim, the analysis of emissions can be done having interest in different scales: global, national, household, product. When there is interest on emissions of arbitrary demand (sub-national level), it is better to use the EEC approach, which considers all the imports and exports within multiple regions to produce what meets that demand. On the other hand, the EET approach is useful for investigating the aggregated exports and imports at a country level, thus when there is interest on the national and global level (Peters 2007; Hertwich & Peters, 2010).

The applications referring to arbitrary demand are not as many as the one on aggregated trade figures. There is room for further investigation. One example is given by Peters & Hertwich (2006b), who focus on households' environmental impacts, in Norway. The crucial finding is that a significant share of pollution caused by the households is related to imports, and in particular, to the imports from developing countries. Through their investigation the authors cannot only confirm that most of the households' impact comes from mobility and food, but also that for categories like food, business services, clothing, chemicals, furniture, cars, agriculture, textiles, and most manufactured products the largest part of the emissions takes place outside the Norwegian boundaries.

Much more attention has been given to the total amount of carbon embodied in the aggregated trade flows at international level. Those studies are helpful in understanding the environmental and trade profile of countries. They point out how production and consumption may diverge in any investigated country.

Environmentally extended input-output analysis is gaining the status of a sound top-down method to calculate the embodiment of pollution and resources in the final demand and trade. The several applications, in a way, attest to its popularity. But not only, the EIPOT (Environmental Impacts of Trade) project[3], established by the SKEP (Scientific Knowledge for Environmental Protection) network in 2008, had the aim to develop a "suitable methodology to assess transnational environmental impacts through international trade". After one year of investigation, EIPOT surmises (Wiedmann et al, 2009) that environmentally-extended multi-region input-output framework represents a suitable ideal basis for assessment of environmental effects of trade. Each application then might be specified and refined with bottom-up techniques as required. Disaggregation and hybridization with LCA may turn out to be useful practice in relation to the specific policy and research purposes. The final remark from EIPOT is the recommendation to use EXIOPOL[4] data which will allow higher disaggregation for environmentally relevant sectors. Brand new data from EXIOPOL project are available from October 2011. Despite the several opportunities, MRIO has some tricky sides.

8. Advantages of consumption-based approach

The designing of any climate policy without taking into account the carbon embodiment of trade might turn out to be ineffective. It is likely to occur especially when it is discovered that the size of the carbon embodiment is both significant and increasing. The recent evidence provided by Peters et al (2011) shows that global CO2 emissions for the production of exported

[3] http://www.sei.se/eipot/

[4] EXIOPOL is a project funded by the European Commission under the 6th framework programme, priority 6.3 Global Change and Ecosystems. The consortium comprises a large number of partners and covers a variety of relevant research expertise in the field of environmental valuation and Environmentally Extended Input-Output assessment.

goods have increased from 4.3 Gt CO2 in 1990 (20% of global CO2) to 7.8 Gt CO2 in 2008 (26% of global CO2). From 1990 to 2008, emissions released for the production of exports amounted to 4.3% per year, more than what occurred for population (1.4% per year), CO2 emissions (2% per year) and GDP (3.6% per year), but less than international trade (12% per year -expressed in dollars). These studies underline that a net emissions transfer is taking place between the Annex B countries and non-annex B. For example, despite Europe's 6% reduction of its territorial emissions from 1990 to 2008, a net emissions transfer from non-Annex B countries has more than offset it. In particular, the same has occurred for the Annex B countries in aggregate. An amount of 16 Gt CO2 has been relocated from Annex B to non-Annex B over the years 1990-2008. Those results show that a significant share of the growth in Annex B consumption is officially computed in emissions inventory of non-Annex B countries. They reveal that behind the Annex B's "official reduction" recorded by statistics as requested by UNFCCC, a positive net emission transfer is hidden. Consumption-based inventory helps in highlighting this phenomenon.

Why might it be important to extend the territorial-based approach and include the accounting of transnational links among economies? The overall impact deriving from goods and services consumed globally should be fully estimated in order to entirely understand the overall (environmental, economic and social) effects of consumption and promote policies for sustainability that might be effective and neutralize distortions. The relevance of these estimations is particularly important in a society like the current one, which is ever more globalized.

The fundamental gain deriving from the reliance on consumption-based inventory is quantifying how much of a country's consumption comes from other countries. Even though it could be extensively debated on the attribution of responsibility for emissions embedded and relocated by trade "Should the producer or the consumer be considered responsible?", it is quite straightforward to perceive how relevant the additional information provided by such an inventory is. Once the embodiment is highlighted, it can be used for manifold purposes. One could be, for example, requiring more substantial commitment from those countries which turn out to be net importers of GHG.

The consumption-based approach that allows discriminating if a country is either CO_2 net exporter or net importer, offers an improved understanding of a country's pressure on climate. Consumer responsibility might represent a first step in increasing participation in the global mitigation action. This kind of perspective might help in raising acceptance among those countries that see committing themselves to binding targets as an unfeasible restriction to their economic development. Finally, a more comprehensive knowledge of each country's emission weight can help in negotiating and agreeing on future international climate policy for the post-Kyoto phase.

Peters (2008) provides a rather straightforward summary on the benefits from using consumption-based NEI. It:

- accounts for international trade;
- covers a larger part of global emissions even with limited participation;
- increases mitigation options;
- naturally encourages cleaner production;
- makes policies like CDM a natural part of the NEI.

Politically, rather than methodologically speaking, opportunities encompassed by the consumption-based accounting approach are summarized by Wiedmann *et al* (2009, p.211) as follows :

> • "CBA complements the territorial-based approach adopted by UNFCCC, by taking into account all consumption-related GHG emissions.
>
> • By providing complementary information, CBA is helpful for international policy on climate change, in particular for addressing participation of developing countries, carbon leakage, and competitiveness issues.
>
> • CBA provides a better understanding, useful when it comes to implementing the ideas of common but differentiated responsibility among the different countries.

• CBA quantifies the economic and environmental trade linkages between countries, aspects that can be useful in designing an internationally harmonized pricing system for GHG emissions.

• CBA could encourage and facilitate international cooperation and partnerships between developing and developed countries. For example it can help in ranking CDM projects or other interventions in developing countries.

• CBA can turn out to be a suitable (communication) tool to make consumers aware of GHG emissions embedded in their choices.

• CBA uncovers hot spots and non-sustainable consumption patterns, thus it is handy when it comes to design strategies on sustainable consumption and production, and mitigation and adaptation policies at the different levels".

The adoption of a consumption-based approach can entail some drawbacks (Peters, 2008):

- More complex calculations and assumptions, thus more uncertainty, even though the allocation of international transport in both cases is related to uncertainty.
- Total shift of responsibility to consumption, which might be alleviated by adopting "shared responsibility" approach.
- Need for policy makers to look beyond the traditional geo-political regions.

Nonetheless, a number of unsolved queries remain , i.e. "first, what political power does a country have to enforce mitigation in a trading partner. Second, if the country pays for mitigation in a trading partner then how are they attributed the emission reductions?" (Peters, 2008, p 20).

8.1 Comparing consumption and production approach

Some studies have provided quantitative evidence on how the adoption of the consumer-based perspective might mean an increase in the amount of emissions attributed to certain countries, especially developed ones.

Ahmad & Wyckoff (2003) confirm that in several OECD countries, for example the United States, Japan, Germany, France and Italy, the emissions associated with consumption are higher

than the ones associated with production. For 10 of the Annex B countries, consumption-based emissions are 550 Mt CO_2 larger than production-based ones. These findings suggest that estimates of emissions based on domestic consumption, which account for trade, are a useful complement to the more standard indicators of domestic production, especially for some countries.

According to Peters & Hertwich (2008b)'s calculation on 2001 data, only 9 out of the 35 Annex B countries have lower emissions when a consumption-based instead of production-based approach is adopted. The majority of Annex B countries are net importers of carbon. In particular, by passing from the production-based approach to the consumption-based approach:

- The EU27's emissions increase by 564 Mt CO_2 (12.8%)
- The US's emissions increase by 439 Mt CO_2 (7.3%)
- The Annex B's emissions increase by 822 Mt CO_2 (5.6%)

Globally emissions embodied in trade are 5.3 Gt CO_2 and Annex B countries are net importers.

Recently, Peters et al (2011) have shown data confirming the findings of previous studies. By using territorial-based emissions evaluation, China is the largest emitter of CO_2 and USA the second. But, when adopting the consumption-based emissions approach, the reverse case occurs: USA is the largest contributor of CO_2 while China is the second. Peters et al (2011) highlight that the increase of consumption in the Annex B countries is recorded in emission statistic of non-Annex B countries. Within Annex B countries (from 1990 to 2008), the net emission reduction of 0.3 Gt CO_2 (about 2%) measured through the territorial-based method, is more than offset by the net emission transfer of 1.2 Gt CO_2

Results above show considerable carbon embodiment in international trade. Taking this aspect into account it gives a more reliable description of countries' pressure on climate.

9 Concluding remarks

Consumer-based emission accounting, by being trade-adjusted, provides additional scientific evidence. A large amount of carbon moves together with trade flows. Several studies confirm that Annex B countries are net importers of carbon. By adopting the consumer-based approach, the majority of emissions embodied in global trade could be connected to the developed economies(Peters & Hertwich, 2008).

Peters (p.21, 2008) defines consumption-based inventories as "a type of border adjustment but not in the form of a tax". MRIO has become a sound method.

Unsolved issues remain. If, thanks to the consumption-based approach, it is found that there is a high degree of displacement of production and emissions to developing country, what can be done? Should the government of that country get actively involved and promote mitigating activities abroad? Or should the same government avoid intervention because it is not its business and it is out of its jurisdiction?

Consumption-based accounting provides the basis for the implementation of policies, like Border Carbon Adjustment, which aims at counteracting carbon leakage, competitiveness and participation concerns that might arise together with sub-global climate policies. If a border carbon instrument has to be implemented, it is necessary to start from measuring the amount of emissions embodied in trade. The adjustment might work in relation to the carbon embodiment of both imports and exports. Adjusting in relation of imports' embodiment leads to leveling the playing field in the domestic market. The adjustment with respect to the embodiment of exports leads to leveling the playing field in the foreign (international) market.

Since several studied shows that emissions transfers via international trade are a significant share of country, regional and global emissions, trade-policy and climate-policy should not be separated. This applies especially in a framework where climate policy actions are sub-globally

implemented, like in the current one. In such a framework it is fundamental to analyse the influence that interventions on trade may have on (climate) mitigation costs and strategies, regardless of whether carbon leakage is nowadays caused by climate policies or not (Peters et al., 2011).According to Peters (2008), even though it is likely that production-based inventory will keep a leading position, since it is less uncertain, consistent with political and environmental boundaries, and relies on already established reporting, consumption-based inventory could still play an important role when it comes to supporting the analysis and climate policy.

10 Background on BCA

The global dialogue the United Nations Framework Convention on Climate Change is overarching, so far only sub-global policy measures have been put in place to handle it.

The theory says that unilateral carbon mitigation interventions endorsed by a small group of keen actors, risk producing distortions in competition and, in turn, generating carbon leakages.

When a country unilaterally decides to carry out an ETS, a carbon tax, or any alternative policy tool whose effect is the generation of explicit or implicit prices on CO_2 (i.e. standards), domestic firms are likely to be negatively affected, since the costs they must bear become higher. In turn, this generates distortion in the companies' playing field vis-à-vis the rest of the world. Major subsequent risks can be profit contraction, market share shrinkage, job losses and carbon leakages.

The case of an uneven playing field for producers appears to be an actual problem, now more than ever. Worldwide nations convened in recent Conferences of the Parties (COP-15 in Denmark and COP-16 in Mexico) have agreed upon no binding long-term global climate action yet. Even though principles like the "common but differentiated responsibility" have been settled, still no consensus prevails on who should bear the responsibility and who should pay.

In order to offset potential asymmetries, not only stakeholders within the Annex I countries are searching for counterbalancing actions, but also a number of policy makers intend to look for ways to reduce their industry's disadvantage with respect to the rest of the world.

There is a broad set of policy measures able to complement a unilateral carbon mitigation scheme. For example, in case of an emission trading scheme (ETS), besides measures creating a similar carbon price that can derive from international agreement – adjusting carbon costs upwards –, like sectorial agreement and linkages among several ETS, other feasible measures are either the ones mitigating the costs imposed by the system itself –which adjust carbon costs downwards –, like free allocations and a scheme of investment subsidies, or the ones at the border, which aim at turning the international trade arena into an even playing field. Concisely, they can be grouped into instruments that level costs downwards or upwards, and the ones at the border, reacting flexibly to cost differentials (Droge, 2009).

The present section aims at shedding some light on relevant aspects concerning the latter, i.e. Border Adjustment measures. The suitability of BCA in offsetting carbon leakage and competitiveness concerns has been increasingly discussed in many political and academic fora within OECD countries. Among others, political proponents are American Senators Kerry and Graham […]And opponents to the tools are not missing. China and India are leading the dissent […]Debate is not over even within the Academia. BCA's effectiveness, its potential in terms of trade-distortion (thus in losses of efficiency), and related administrative and legal issues (mainly consistency with WTO rules) are the most discussed points. All in all, no country has implemented this kind of tool yet. One of the major worries about the instrument is the risk of a trade war. http://ictsd.org/i/news/bridgesweekly/59235/

Who is considering the actual implementation of BCA?

A prominent case is represented by the European Union and its Directive of 2009 which revises the previous one concerning the European Emission Trading Scheme. This directive mentions the necessity of an effective **carbon equalization system,** to place the Community's installations at risk of carbon leakage "on a comparable footing" with those from the rest of the

world. Either 100% allowances free of charge or requirements to importers are designated as potential options (European Commission, 2010).

[BENCHMARKING for FREE ALLOCATION http://ec.europa.eu/clima/policies/ets/benchmarking_en.htm27 Apr 2011: Emissions trading: Commission adopts decision on how free allowances should be allocated from 2013] Additional proponents of BCA are the USA, whose House of Representative has approved the American Clean Energy and Security Act (H.R.2454), usually referred to as the Waxman-Markey Bill, in 2009. Even though not explicitly raising the competitiveness issue, it states as a prime aim the avoidance of GHG emissions enlargement in countries other than the US. The advocated way to do so is a mandatory requirement for importers to purchase allowances (U.S. Congress, 2009).

10.1 BA Definition

BA is "any fiscal measure which puts into effect, in whole or in part, the **destination principle** (i.e. which enables exported products to be relieved of some or all of the tax charged in the exporting country in respect of similar domestic products sold to consumers on the home market and which enables imports sold to consumers to be charged with some or all of the tax charged in the importing country in respect of similar domestic products" (GATT, 1970) "BA is a trade measure designed to level the playing field between domestic producers facing costly climate policy and foreign producers with no or little constraint on their GHG emissions" (Monjon & Quirion, 2011)

Border tax adjustment (BTA) might be a restrictive way to refer to border adjustment (BA) measures, because in addition to taxes and tariffs, it is also possible to implement allowance-based instruments. Since the focus of the current report will be on the climate change issue, the definition that is going to be used is carbon-motivated border adjustment measures or, shortly, border carbon adjustment (BCA).

10.2 RATIONALE

The rationale behind BCA has been frequently associated with the following matters (ICTSD, 2010 http://ictsd.org/i/news/bridgesweekly/59235/; Cosbey, 2008):

1) Carbon leakage.
2) Competitiveness. Burniaux et al. (2010) talk about "political economy rationale", mentions that, even when leakage may be a minor worry, energy intensive industries producing homogenous tradable goods may experience substantial competitiveness and output losses, thus lobbying for supporting measures. And this is actually what has being occurred in Europe and in the United States too.
3) Incentives for further countries to implement carbon policy tools as well. In this case BCA are used as a leveraging point.

when it comes to **competitiveness it is relevant to look at the**: function of market structure, industry technology, extent of import competition, design of the climate policy, domestically and abroad. Related to the former issue is the issue of**carbon leakage** , whose consequences are both the creation of carbon havens and job losses (Sheldon & McCorriston, 2011).

10.3 Concept of Carbon Leakage

The term carbon leakage refers to producer and consumer reactions to unilaterally implemented climate mitigation measures (Droge, 2009).

Strong carbon actions endorsed domestically can induce production relocation or market share losses to those countries without a comparable system in place. Thus, uneven policy tools could result in shifts of production activity and consumption patterns in favor of foreign supply, and in turn, in a "transfer" of emissions. Emissions relocation could end up spoiling to some extent the effectiveness of the undertaken policy measures. The concern is avoiding at least full or more than offset of emissions

Unilateral carbon measures have the potential to affect global emissions through diverse channels. first, is the "international energy market", second, "firms' production costs and their operation and investment decisions", and last, "the dynamics of technological innovation and policy diffusion". Looking at the most investigated case, i.e. the second one, it emerges that it consists of two components: 1) The "operational leakage", which is the short and medium term effect, consisting of the relocation of production towards facilities outside the product policy tool scope, and 2) the "investment leakage", i.e. the long period consequence, resulting in production relocation outside the geographical areas embraced by the climate mitigation measure (Droge, 2009).

Reinaud (2008)states "Unilaterally implemented policy tools can generate distortion of competition (especially for sectors with international exposure - aluminum, steel and (to a lesser extent) cement - and with a degree of process and product homogeneity. (NB: emission-intensive sectors/ electric intensive sectors)

1) Environmental: carbon leakage (a. Short term competitiveness channel, b. Investment channel, c. fossil fuel price channel); 2) Social: job losses"

11 Possible design of a BA

The existence of measures unilaterally addressing climate change mitigation is a sort of prerequisite for BCA, which actually is an adjustment measure. Then, when it comes to implementing BTA, several decisions about the different design features have to be taken. The many design aspects show intrinsic trade-offs in terms of administrative feasibility on the one hand, and effectiveness together with WTO compatibility on the other hand.

SEE COSBEY 2008a ; MONJON&QUIRION 2010; prime 2 pag di Burniaux 2010; Reinaud 2008; Droge (2009)

BCA's crucial aspects are its form, its coverage and the adjustment base (Monjon & Quirion, 2011).

11.1 Form

BCA can either be tax-based or allowance-based. By adopting a **price-based** measure, a tax on imports, a rebate on exports or both might be introduced. As an alternative, a **quantity-based** method could be chosen, introducing either an obligation to purchase allowances for importers, or both the former and an exemption to surrender allowances for exported goods.

Either choosing the tax-based or the allowance-based approach, BCA could be defined: 1) in order to adjust the level of greenhouse gases released during the diverse production steps of each imported and/or exported product; 2) in a standardized way, differentiated either on product category or country basis, no matter the process, and reflecting the domestic carbon content or alternatively the foreign one. 3) In a standardized way but also allowing exporters to prove their higher efficiency, if any (Kommerskollegium, 2010). *http://ictsd.org/i/news/bioresreview/97116/*

By taking into account that a market for carbon allowances has already been working in Europe since 2005, in case of BCA it would make more sense to go for a quantity-based solution complementing it.

11.2 Coverage

11.2.1 SECTORS

According to not only the literature, but also the two above mentioned official documents, i.e. EC Directive 2009 and Waxman-Markey Bill, a border adjustment mechanism should be applied to those sectors likely to be damaged by a persistent and considerable CO_2 price differential.

Such **sectors** are the ones that can 1) face high direct costs due to high CO_2 emissions content in production process 2) face high indirect costs because of the large use of electricity 3) be exposed to international competition 4) not be able to "pass-through", that is, shift the increase in costs further along the value chain, through the price channel.

In particular, the European Commission identifies 164 exposed sectors and subsectors (collection then reviewed and enlarged by the Council) on the basis of trade intensity and additional CO_2 cost - added value ratio. In the Waxman-Markey Bill "the eligible sectors" are

defined looking at certain thresholds when it comes to energy intensity, GHG intensity and trade intensity.

For the above mentioned reasons, when assessing the potential impacts of a BCA it would be relevant to keep in mind respectively the 1) CO_2 intensity of production 2) the energy and electricity intensity of production 3) the trade intensity 4) elasticity of demand

11.2.2 IMPORTS/ EXPORTS

BCA can be designed in order to address both **import and exports**, or only imports. While an intervention on imports intends to level the producers' playing field within the domestic market, the one on exports aims at reducing asymmetries when it comes to competing in the foreign arena. BA embracing both imports and exports would better address the issue of carbon leakage, but will not necessarily improve the tool's performance under the global emission reduction perspective. For this reason, a BCA covering exports can be more difficult to justify while appealing to Article XX in a WTO dispute.

The mentioned phenomenon is explored, for example, by Monjon&Quirion (2009) who find out that, not only without BA a leakage-to reduction ratio of 10% takes place, but also that the ratio is negative with an imports&exports solution and almost nil when only imports are addressed. Commenting on these findings, an import-based option still looks good enough to tackle carbon leakage. So, the claim for exports inclusion is usually up to domestic companies wishing to preserve their competitiveness.

11.2.3 PRODUCTS

Which **products** should be embraced by the BCA system? Generally speaking, the number of products encompassed by the BCA should not be too large in order to avoid an excessive administrative burden.

More sensitive is the issue of inclusion of downstream products, since introducing a BCA measure on a "primary product" (i.e. steel) but not on goods placed further down on the value chain (i.e. cars), would incentivize the relocation of the latter's production outside the geographical scope of the policy action. But still, BCA cannot be applied to all products within the chain. Also because, what really matters in evaluating the BCA efficiency it is not the CO_2 content of all the goods in absolute terms, but the marginal variation of CO_2 in the two climate

policy scenarios, the one with and the other without BCA.The decision of whether or not to include scraps, for carbon minimization, is also tricky.

When it comes to taking decisions on BCA product scope, different approaches can be adopted, ranging from the maximalist to the minimalist one. it is also relevant to state whetherdownstream goods should be included or just the primary products, considering that the choice can affect both trade patterns and carbon leakage (Monjon & Quirion, 2010). Administrative arrangements and costs will significantly vary in relation to BCA product scope.

11.2.4 COUNTRIES COVERED

BCA is expected to tackle asymmetries among countries and, in theory, discrimination among the trade partners could be fair. Those that are underpinning comparable actions should be reserved a different treatment than those carrying out no climate measures.

The best solution would be a multilateral BA where those countries with comparable policies implement a similar BA, with adjustments occurring only in relation to“no-BCA countries” (Monjon & Quirion, 2010). The differentiation risks originating **circumvention** phenomenon and, moreover, it is likely to be blamed of violation of the most-favored-nation WTO rule.

Moreover, one way to (mitigate/reduce) the threat could be to put into place a product-based (instead of country-based) BCA.http://ictsd.org/i/news/bioresreview/97116/

12 GHG reduction policies and measures and the WTO: An evaluation of the legal aspects related to the inclusion of Border Carbon Adjustments in international trade

Within the ongoing international debate regarding the most effective policies which should be developed in order to mitigate climate change, concerns are arising about the potential incompatibility between GHG reduction policies and measures (PAMs) and international trade rules. When countries implement PAMs which other countries do not adopt or when PAMs present strong differences between countries, consequently producers around the world face different costs and risks. This leads to concerns that production of goods will

relocate where climate change mitigation obligations are not applied impacting? competitiveness and carbon leakage. The latter consists of the climate implications of differential mitigation costs among nations in terms of production and trade. If one country's GHG emissions reduction commitments induce producers to shift their production to countries where similar commitments are not in force, emissions would not be reduced but simply shifted to another country. A related concern is that different carbon constraints would force competitiveness and increase profits and market share of producers based in non-carbon-constrained countries. Such concerns have partially contributed to the failure of several proposed environmental PAMs over the last decade.

The legal feasibility of every option addressing carbon leakage and competitiveness needs to consider both international agreements governing trade and climate change. The potential friction between these two fields could be summarized in the following two principles:

1. Climate Change: "Common but differentiated responsibilities" (CBDR) represents a key principle of the United Nations Framework on Climate Change which drove the Kyoto Protocol since its first steps and which was espoused in the Bali Action Plan of 2007. According to CBDR countries should contribute to the reduction of GHG emissions in line with their historical responsibility and current capacity. Any PAM which would equally distribute the burden of the mitigation among all the countries would not fulfill this principle.

2. Trade: One of the core principles of World Trade Organization legislation is non-discrimination between "like" goods. How a good is produced does not represent one of the criteria to define "likeness" of goods, but according to GATT article XX there are a few exceptions which can be invoked against a short list of criteria, one of which is environmental benefit. Therefore any policy option which would seek only to protect domestic producers for economic reasons could not be saved by this exception.

GHG PAMs can be distinguished as follows:

1. Border Carbon Adjustment (BCA):

a. Border Taxes (normally as tariffs on imports, more rarely as rebates on exports);

b. Mandatory Allowances Purchase by importers;

c. Embedded Carbon Product Standards;

2. Alternative Options:

a. State Aid to Industry (e.g. public subsidies to sectors with low carbon technologies);

b. Free Allocation of allowances to domestic producers;

c. Sectoral Approaches.

BCAs have been proposed as a companion to either a domestic carbon tax or a cap-and-trade scheme.

In case of a carbon tax, a BCA would consist of charging imported goods the equivalent of what they would have to pay had they been produced domestically. In the case of a cap-and-trade scheme, a BCA would force domestic importers or foreign exporters of goods to buy emission permits corresponding to the amount of carbon emitted within the production process, as requested to domestic producers[5].

To evaluate the legal feasibility of border carbon adjustments (BCA), such as import levies, it is necessary to analyze them with regard to both the current climate change policy and regulation and international trade rules.

[5] See J. de Cendra, *Can Emissions Trading Schemes be Coupled with Border tax Adjustments? An Analysis vis-à-vis WTO Law*, 15 RECIEL 131 (2006).

To evaluate the legal feasibility of border carbon adjustments (BCA), such as import levies, it is necessary to analyze them with regard to both the current climate change policy and regulation and international trade rules.

Article 10 of the Kyoto Protocol identifies industrialized countries as the main contributor to the climate problem, but also as the actors with the greatest capacity to face and solve it. This is reflected in the above mentioned principle of "common but differentiated responsibilities".

By imposing a CO2–dependent import tax with a consequent disadvantage for developing countries' exportation of goods the burden created by climate policies adopted by industrialized countries might start shifting and resting on emerging economies in violation of the common but differentiated responsibilities principle.

It could also be argued that BCA might undermine the negotiated balance of responsibilities for mitigation actions within the climate change regime, which has set urgent emissions reduction targets for developed countries, deferring the involvement of developing ones not to restrict their development.

Concerning international trade rules they are embodied in the World Trade Organization (WTO), as well as in several regional and bilateral trade agreements. To say whether BCA would or would not breach WTO law it is essential to know how the adjustment scheme would be designed:

- As a tax which is meant to make importers pay the same price domestic producers paid in a domestic carbon tax regime (Border Tax Adjustment, BTA).

or

- As a requirement to buy allowances at the border in order to compensate the requirement for domestic producers to participate in a cap-and-trade scheme.

In case of a carbon tax, a BCA would consist in charging imported goods the equivalent of what they would have to pay had they been produced domestically. In the case of a cap-and-trade scheme, a BCA would force domestic importers or foreign exporters of goods to buy emission permits corresponding to the amount of carbon emitted within the production process, as requested to domestic producers[6].

Under 1994 General Agreement on Tariffs and Trade (GATT), BTA appears to be theoretically allowed as long as it is non-discriminatory. In fact, as a core principle, WTO law, through GATT, Articles II:2(a) and II:2 permits the use of border tax adjustments which are imposed equally to both domestic and imported goods. This represents one the core principles of WTO law contained in GATT, namely the National Treatment principle according to which governments should treat foreign products no less favorably than "like" domestic products[7].

Secondly BTA, as well as the requirement to purchase offsets at the border, should comply with the Most Favored Nation principle (MFN), set out in GATT Article I according to which: "…any advantage, favor, privilege or immunity granted by any contracting party to any product originating in or destined for any other country shall be accorded immediately and unconditionally to the like product originating in or destined for the territories of all other contracting parties." Therefore there should not be any discrimination between like products based on where they have been produced. Rules and regulations for like imported products should not favor any importing country over another. It means that any BCA should treat products, such as for example cement, from different foreign producing countries equally. A BCA which would distinguish based on different countries' climate change policies or focus on the trading partners of major commercial interest would, in both cases, violate MFN and breach WTO law.

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[6] See J. de Cendra, *Can Emissions Trading Schemes be Coupled with Border tax Adjustments? An Analysis vis-à-vis WTO Law*, 15 RECIEL 131 (2006).

[7] See *European Communities – Measures Affecting Asbestos and Asbestos-Containing Products*, Report of the Appellate Body (WT/DS135/AB/R) 12 March 2001, para. 99-101. In this report the WTO's Appellate Body has ruled that likeliness "*is, fundamentally, a determination about the nature and extent of a competitiveness relationship between and among products*". Likeliness has been defined as being determined by four criteria: i) the (physical) properties, nature and quality of the products; (ii) the end-uses of the products; (iii) consumers' perceptions and behavior in respect of the products; and (iv) the tariff classification of the products.

A tax adjustment on the basis of emissions embodied in the energy used in the production of goods could also be blamed as contravening GATT's Article III:2, according to which taxes and internal charges on imports should not be applied exceeding those applied to "like" domestic goods.

Whether an imported good which has been produced in a non-carbon-constrained country can be considered "like" a domestic good which has been produced following GHG reduction requirements cannot be stated without investigating whether WTO law (GATT) allows for discrimination not only on the basis of product characteristics, but also on the basis of production and process methods (PPMs)[8].

PPMs could be product-related or non-product related. The latter ones are not physically incorporated in a product. GHGs emitted in the production process would then be listed as non-product-related PPMs and, according to some authors, should not be considered to affect the likeness where imported and domestic products are competing in the relevant market.

Therefore any measure applied to imported products on the basis of different non-product-related PPMs could be accused of breaching GATT's Article III, while product-related PPMs, affecting the competitiveness between domestic and imported products, could make non-likeness of two products self evident without violating the non-discrimination requirement of Article III.

Other authors together with the most recent WTO jurisprudence disagreed with the above interpretation supporting the opposite idea that border adjustments could also be applied to non-product-related PPMs, with no violation of national treatment provisions. This idea is supported by the combined language of Article II:2(a) and Article III:2. According to the latter one imports "shall not be subject, directly or indirectly, to internal taxes or other internal

[8] As underlined by Low, P., Marceau, G., Reinaud, J. a determination of the likeliness of two products depends on whether they compete in the market. The main criteria which are normally used to make such a determination are: a) the physical characteristic of the products; b) their end use; c) consumer preferences; d) the tariff classification applied to each product.

charges of any kind in excess of those applied, directly or indirectly, to like domestic products". As an environmental tax, a carbon tax could be identified as an internal one subject to the discipline of this article. Article II:2(a) allows the imposition of charges on imports equivalent to internal taxes imposed "in respect of an article from which the imported product has been manufactured or produced in whole or in part". Both concepts of direct and indirect charges and inputs used in whole or in part in the final product have been cited to support the above different interpretations. On the other hand the interpretation of these two provisions is currently far from being unanimous.

In fact, according to the interpretative Note Ad Article III "any internal tax…which applies to an imported product and to the "like" domestic product and is collected and enforced in the case of the imported product at the time of importation, is nevertheless to be regarded as an internal tax". Therefore, since internal taxes can be adjusted at the border or anywhere else in the distribution process the same should be feasible with a carbon tax.

However environmental taxes have to be further distinguished as, taxes on products, resources, uses or inputs. The latter ones can find their leading case in US Superfund which stated that taxation of physically incorporated inputs, namely articles used for the manufacture of domestic products may be taken into account in border tax adjustments of imported "like" products. This was confirmed by GATT's Panel[9].

Taxes on carbon emissions or energy apparently could be included in those applied on inputs, but on this point GATT is not clear. Indeed Article II(2)(a) seems to preclude BTA for such taxes since it allows a tax on inputs "from which" and not with the use of which the imported and the domestic "like" product were produced[10].

[9] BTA con be made, for example, for a tax on chlorofluorocarbons (CFCs) and other ozone-depleting substances with respect to the export/import of refrigerators in which they are incorporated. See GATT Doc EPCT/TAC/PV/26, at 21 (1947), quoted in *US Superfund*, para. 5.2.7.
[10] See OECD/IEA, *Taxing Energy:Why and How* (Paris, 1993)

This controversial issue is currently discussed by the WTO Committee on Trade and Environment (CTE)[11].

Coming to the option of requiring importers to purchase offsets at the border as opposed to BTA, it would, as a regulation, be covered by GATT Article III:4, which requires that imports be accorded regulatory treatment "no less favourable" than that accorded to "like" domestic products. Within this context the concept of "likeness" is slightly more loosely interpreted than under Article III:2. Therefore it is not clear which interpretation could be given by a panel in a case that discriminated on the basis of the GHG-intensity of production. If the products were considered "unlike" such discrimination would clearly be allowed.

For both taxes and purchase requirements, an eventual breach of the Article I and Article III obligations, would not be the final word on GATT legality. Indeed Border Carbon Adjustments which would violate one of the above mentioned principles could still be acceptable if qualified as exceptions to WTO law. In fact GATT Article XX gives WTO Member States limited policy space to pursue certain listed aims. Regarding BCA, they could still be considered legal according to Article XX if:

"(b) necessary to protect human, animal or plant life or health;"

and

"(g) relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption;"

The above mentioned exceptions could be called upon unless measures would not be applied "in a manner which would constitute a means of arbitrary or unjustifiable discrimination…,or a disguised restriction of international trade"[12].

[11]See on this topic P. Birnie, A. Boyle and C. Redgwell, *International Law and the Environment*, 2009, Oxford Press, pp. 796-801. See also E. Malathouni and D. Prevost, *An International Trade Law Perspective on Sectoral Greenhouse Gas Emission Mitigation Approaches*, 2009, Maastricht University, available on http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1417343 .

Even though Article XX(b) would seem a broader and therefore more suitable exception for BCA violating Articles I and III, most analysts agree that climate change measures are more likely to be justified by Article XX(g), due to the fact that the atmosphere could arguably be considered as an exhaustible natural resource. However this interpretation would require BCA to "relate to the conservation of natural resources" and to be "made effective in conjunction with domestic restrictions". If no doubt should arise regarding the first requirement, the second might not be fulfilled if domestic producers would be given free allowances while importers would have to pay for them. In fact the treatment of domestic goods and imported ones should be equal and impartial.

Assuming BCAs would most likely be accepted as covered by one of the above mentioned exceptions there is a final question to be considered, namely if BCAs would also fulfill Article XX's "chapeau" obligations. The chapeau requires that: "... measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade …". The Article XX chapeau inevitably has relevant implications for how a BCA is applied, and somehow designed, but its changing interpretation does not allow making a prediction about how it would affect the application of each possible measure.

As has been underlined by the latest WTO-UNEP Report, WTO jurisprudence has pointed out some circumstances which need to be taken into consideration when assessing measures' compliance with the above mentioned chapeau. They can be summarized as follows:

- relevant coordination and cooperation activities undertaken by the defendant at the international trade level? in the trade and environment area;
- design of the measures;
- flexibility to take into consideration different scenarios in different countries;

[12]See GATT Article XX.

- rationale presented as the explanation of the existence of a discrimination (such rationale should be connected to the main purpose of the measure)

On the basis of these criteria the WTO Appellate Body, in the *US-Gasoline* decision, "considered that the United States had not sufficiently explored the possibility of entering into cooperative arrangements with affected countries in order to mitigate the administrative problems raised by the United States in their justification of the discriminatory treatment." In the *US-Shrimp* case the decision taken by the United States to adopt a cooperative approach regarding the protection of sea turtles only with some WTO Members was considered as discriminating among WTO Members in an unjustifiable manner.

As Cosbey (2008) suggests on the basis of case law any BCA that hopes to conform to WTO obligations should take into account three core requirements of interest:

- Consider all policies and measures adopted by other trading partners which could have direct effect on climate change. As for example is the case for the EU, when evaluating if some exporting country's measures to face climate change are comparable to EU ones, should not expect an identity of measures but consider if those which have been implemented by that country might produce, in the end, equivalent results.

- Secondly BCAs should avoid referring to generalized national baselines of carbon intensity of production from a certain sector taking instead into account the differences between individual producers. In fact by using national indicators, efficient producers from countries with a low average of carbon efficiency would be unequally penalized.

- Third, BCAs, as unilateral measures to implement environmental policies, should be adopted only in the case of a lack of multilateral agreement to address the problem at the end of an unsuccessful process of negotiations. In this respect BCAs applied to Kyoto Parties such as India or China might be legally argued. In fact there are no doubts

regarding the fact the Kyoto Protocol is a strong multilateral agreement obtained with large consensus[13].

On the basis of the above mentioned criticisms a trade dispute would arguably arise if a BCA would be implemented unilaterally or without paying sufficient attention to other countries trade policies.

A WTO dispute settlement panel could theoretically come to one of the following conclusions:

- The BCA under discussion does not breach WTO law. This result would inevitably undermine UNFCCC's legitimacy as the global standard-setting body for climate change policies;

- The BCA under discussion does violate WTO law. This would likely induce UNFCCC and the rest of the environmental community to criticize the trade regime assuming it is sitting in judgment of climate policies.

WTO Members could avoid both consequences by amending the current trade regulatory framework. Following WTO amendment procedures all or the majority of WTO Members should reach specialized agreements or formally exclude certain BCAs from the list of possible measures, based on a widespread concern about both climate change mitigation and respect of international trade rules.

The outcomes of next MEPC 62 and the upcoming UNFCCC COP16 will probably tell more about the real international political intention to address climate change also by developing and implementing new trade measures like Border Carbon adjustments complying with both UNFCCC and WTO law.

[13] See A. Cosbey, *Border Carbon Adjustments*, International Institute for Sustainable Development (IISD), Trade and Climate Change Seminar June 18-20, 2008, Copenhagen, Denmark

13 Conclusions

During the last two decades globalisation has been a key variable driving economic growth and raising the living standards of nearly everyone on the planet, although not without cost. Indeed, the growth in world trade and capital flows resulting from globalisation is now increasingly seen as an issue in the scientific and political debate on the environmental impacts of global supply chain and consumption.Most cost efficient locations around the world accelerate the trends towards international specialization causing some distortions of the markets in terms of the use of natural resources.

The relative international competitiveness of companies in nations with stronger environmental protection regulations (haven hypothesis) is one argument for looking at alternative global environmental regulatory tools that are compatible with international trade agreements and development policies. Steger and Bleischwitz (2011) recognize that stringent environmental polices can force pollution intensive sectors to move to regions more favorable if the abatement costs are too high.

However, trade is not a driver of environmental degradation, but the structure of the markets and the presence of market failures (externalities, no definitions of property rights) are the causes of environmental impacts.

Moreover, many eminent international efforts work for realizing global sustainable management of natural resources and resources efficiency : OECD. UNEP, World Bank, Rio 20+. In Europe, the Resource-Efficient Europe, one of the seven flagship initiatives of the Europe 2020 strategy in support of sustainable development objectives, defines a framework for policies to support the shift towards a resource-efficient and low-carbon economy.

A sustainable management of global supply chain impacts on environment poses methodological and political challenges. On the one hand, recent scientific literature has advocated to shift from the current production-based quantification of environmental

pressures to consumption-based quantification in order to encourage the design of a more equitable, effective and participatory future global environmental and climate policies (Atkinson et al, 2010; Helm et al, 2007; Munksgaard et al, 2009; Peters and Hertwich, 2008a; Arjen Y. et al, 2012). On the other hand, the international policy debate reflects the need to address these concerns by introducing policy tools compatible with national economy and international trade agreements . Moreover one of the challenges of the resources efficiency policies is to solve the so –called Jevons Paradox defined in 1895 William Jevons. Jevons stated " Every such improvements of the engine, when affected, does but accelerate anew the consumption of coal. Every branch of manufacture receive a fresh impulse – hand labour is still further replaced by mechanical labour. (Jevons, 1865). In the last years, the Jevons paradox has been the conceptual basis of the study on the rebound effects which is of particular interest within the context of the current "Green revolution (green economy or green growth).

With regard to the climate change Consumption-based inventories could represent an alternative. They account for trade and can enhance understanding of the actual origins of carbon emissions. According to Peters (2008), it is likely that production-based inventory will keep a leading position, since it is less uncertain, consistent with political and environmental boundaries, and relies on already established reporting. Nevertheless, the consumption-based inventory could still play an important role when it comes to supporting the analysis and the design of climate policy. The consumption-based approach that allows discriminating if a country is either CO_2 net exporter or net importer, offers an improved understanding of a country's pressure on climate. The fundamental gain deriving from the reliance on consumption-based inventory is quantifying how much of a country's consumption comes from other countries. Once the embodiment is highlighted, it can be used for manifold purposes. For instance, the adoption of consumption-based approach allows consumers participating in the global mitigation action by being conscious of the ecological effects of their choices and, then, responsible of their contribution to GHG. The scientific and methodological debates on consumption-based approach often are accompanied by the political debate on Border measures. In a world of unilaterally implemented climate policy tools and unequal carbon

prices, the consumption-based accounting methods may help to find out the real carbon embodiment of consumption and trade, and, for instance, shaping BCA that addresses the amount of virtual carbon in trade and complements other measures in place. Indeed, Peters (p.21, 2008) defines consumption-based inventories themselves as "a type of border adjustment but not in the form of a tax" introducing very sensitive topic of the international policy debate of carbon and trade. As pointed out, a key question of such debate is if the carbon embodied in products could be the basis for trade measures. Moreover, is the concept of embodied emissions compatible with international trade agreements? Is coexistence possible between embodied carbon discrimination and the existing WTO rules?

Border Carbon Adjustments have been largely discussed within academia and research fora. What is missing is any kind of empirical test[14]. A test would indeed provide the international climate debate with a further pragmatic perspective. Regardless of its outcome, such an experience could be useful in supporting the international community in its pursuit of fair, efficient, effective and global climate action. Indeed, in order to make the any trade policies implementation fairer with respect to those actors in more difficulty and its execution more acceptable in the international arena one option might be to recycle the revenues from any scheme and make them to converge into EU international funds. They could be meant for financing internal and developing countries' mitigation and adaptation efforts towards climate change. The above reasoning make our minds to turn to the Green Climate Fund (decided to be established in COP16, Cancun, 2010) and all the implications involved by its creation. It could be channeled to the developing countries themselves in order to support both their development and their commitment in the global climate effort. This kind of perspective may help in raising acceptance among those countries that perceive their commitment to binding targets as an unfeasible restriction to their economic development. Moreover, a more comprehensive knowledge of each country's actual emission weight can help in negotiating and agreeing on future international climate policy for the post-Kyoto phase. It emerges that policy makers need to look beyond the traditional geo-political regions, and approaching the issue from a consumption-based perspective may already represent a significant step in this direction.

[14] It has to be stressed that the introduction of BCA could be seen as a Green protection action. This is not the objective of this report which provides a critical analysis of such tool.

As a final remark, we would recall the Stiglizt's considerations (2006) on how to make the globalization works with respect to the global warming. Stiglizt (*ibid*) provocatively invites Europe and Japan the most committed States within the Kyoto Protocol presenting an action against the States refusing taking part to international climate policy actions in coherence with the WTO rules as matter of fairness trade. A new approach for the post-Kyoto phase should consider the absence of a climate regulation as a sort of *"illegitimate domestic subsidy"* within the context of the international trade agreements.

This provocative action could be taken in all the international context of global environmental governance in order to accelerate a global sustainable management of natural resources.

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Title: Environmental impacts of global supply chain: a review of scientific, policy and legal components for including environmental and climate challenges within the international trade patterns

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Abstract

During the last two decades globalisation has been a key variable driving economic growth and raising the living standards of nearly everyone on the planet, although not without cost. Indeed, the growth in world trade resulting from globalisation is now increasingly seen as an issue in the scientific and political debate on the environmental impacts of global supply chain and consumption. Most cost efficient locations around the world accelerate the trends towards international specialization causing some distortions of the markets in terms of the use of natural resources.
The relative international competitiveness of companies in nations with stronger environmental protection regulations (haven hypothesis) is one argument for looking at alternative global environmental regulatory tools that are compatible with international trade agreements and development policies. Literature recognises that stringent environmental policies can force pollution intensive sectors to move to regions more favourable if the abatement costs are too high. However, trade is not a driver of environmental degradation, but the structure of the markets and the presence of market failures (externalities, no definitions of property rights) are the causes of environmental impacts. This report analyses the key features of global supply chain and its environmental impacts related to biodiversity loss, water conservation, raw material.
The report provides a deep analysis on Climate change and global supply chain. It analyses the scientific, legal and policy components of the international debate over carbon and trade. It introduces and analyses the concept of the consumption-based approach and compares it with the production-based one. The reports highlights that policy makers should look beyond the traditional geo-political regions and a consumption-based perspective would represent a significant step in this direction in order to manage a sustainable global supply chain.

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