Pollution haven hypothesis in emissions embodied in world trade: *The relevance of global value chains*

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OUTLINE

- ❑ Introduction
- ❑ Methodology
- ❑ Results
- ❑ Conclusions

Introduction

- **Since 1950 global GDP is multiplied by 7 and international trade by 27** (WTO, 2004)**.**
- **International trade represents the 21% of GDP in 2007.**
- **It represents the 26% of the global CO_2 emissions in 2008** (Peters *et al*., 2011)**.**
- **Trade growth cannot be explained only by final goods and raw materials trade:**
  - Increasing fragmentation of production.
    - 2/3 of the international trade are **intermediate goods**

GLOBAL VALUE CHAINS

Introduction

- **In this context…**
  - **Is international trade good for environment? Is there a reduction or an increase of the global emissions?**
  - **Is the GVC rise linked to the seek of comparative environmental advantages?**
  - **How can we analyse it?**
- **OUR TOOLS:**
  - **BALANCE OF AVOIDED EMISSIONS** (López *et al*., 2013) **in a MRIO** (BAFC) **to analyse PHH.**
    - Using WIOD, considering 3 and 7 regions, for 1995 and 2009.

POLLUTION HAVEN HYPOTHESIS

(Copeland and Taylor, 2004)

The growth of international trade leads to an increase in emissions

In a world without international trade…

Emissions are higher or lower?

Introduction

- **There are many contributions of the input-output framework to this topics:**

Emissions Balances (EB) and Responsibility Balances (RB)	• Munksgaard and Pedersen (2001). • Peters and Hertwich (2006 and 2008). • Cadarso et al. (2012). • Davis et al. (2011). • Kanemoto et al. (2012). • Jakob and Marschinski (2012).
Pollution Haven Hypothesis (PHH) – Balances of Avoided Emissions (BAE)	• Dietzenbacher and Mukhopadhyay (2007). • Ackerman *et al.* (2007). • Chen and Chen (2011). • Zhang (2012). • López *et al.* (2013).
Global Value Chains (GVC)	• Hummels *et al.* (2001). • Trefler and Zhu (2010). • Johnson and Noguera (2011).

Methodology

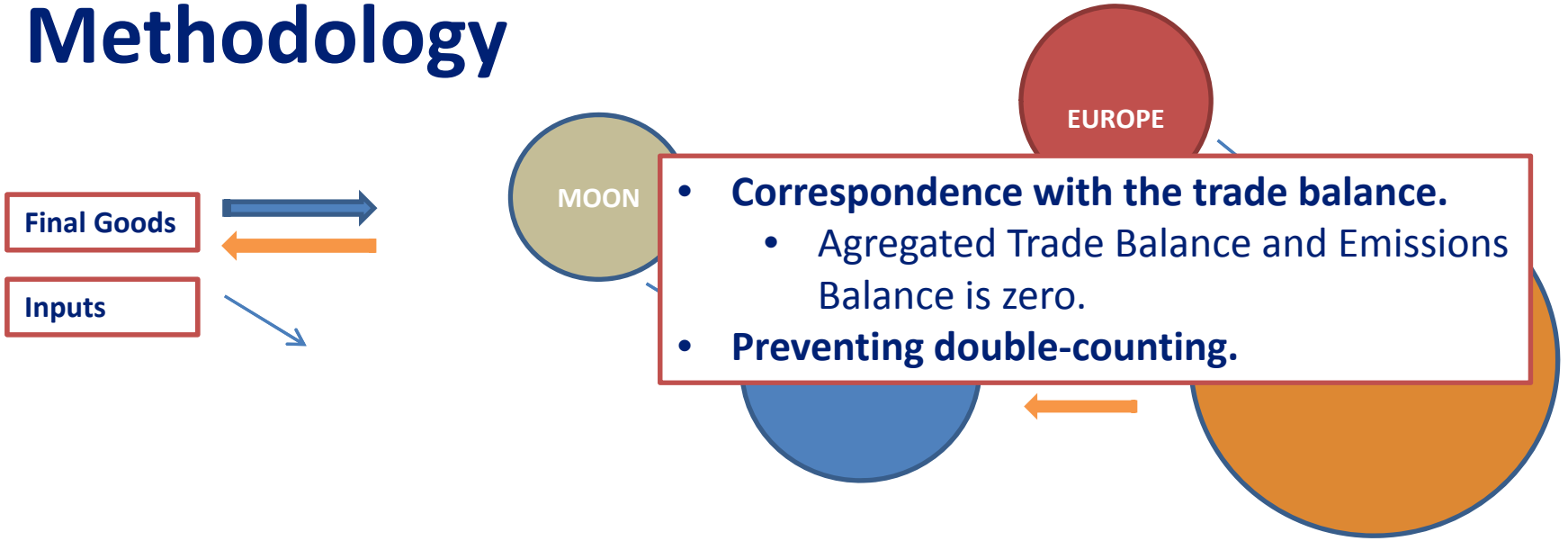
- **World Trade Balance (WTB) → Standardised procedure:**

$$WTB = \mathrm{X} - \mathrm{M} = \sum_{\mathrm{r}=1}^{\mathrm{n}} \mathrm{X}_{\mathrm{r}} - \sum_{\mathrm{r}=1}^{\mathrm{n}} \mathrm{M}_{r} = 0$$

- **For emissions balance there is not standard definition:**
  - **RB, EEBT, MRIO-B, BDEE… →** But at **global level**, all of them **sum up to zero.**
    - Identify **countries** with an "emissions deficit" or "emissions surplus".
    - Identify responsible **industries** (in direct and indirect terms).
- **We extend the BDEE/BDFC and BAE/BAFC for a bi-regional case** (López *et al.*, 2013) **to the case of a MRIO.**

The calculation of the BAFC allows us to evaluate whether international trade increase or decrease emissions at global level:
To evaluate the effect of international trade on the environment.

Methodology



The Emissions Balances Earth – Jupiter under the different assumptions of the literature are:

1. $EEBT^{T-J} = E^{EARTH} - E^{JUPITER}$
2. $EEBT^{T-J} = E^{EARTH} - E^{JUPITER}$

BDEE Final Goods | **BDEE Inputs**

2.1. MRIO-B^{T-J} = ($E^{EARTH} + E^{MOON}$) – ($E^{JUPITER} + E^{EUROPE}$) → **Kanemoto *et al.* (20[illegible]),** Assigns the responsibility to the country as a consumer of final goods, inputs become endogenous.

OUR PROPOSAL → To isolate inputs or GVC

BDEE^{T-J} = (E^{EARTH}) – ($E^{JUPITER} + E^{EUROPE} + E^{MOON}$) = ($E^{EARTH} - E^{JUPITER}$) - ($E^{MOON} + E^{EUROPE}$)

Methodology

- We can calculate the factors embodied in the production of the world economy as follows:

$$E = F(1-A)^{-1}Y = FLY = PY$$

F → Diagonal matrix of emissions intensities.
P = F*L → Factor content multiplier: Total, direct and indirect, emissions.
Y → Final demand.

- We can split up into different elements of final demand or input:

$$E = PY = (P^d + P^m)(Y^d + Y^x)$$

$$E = \underbrace{P^d Y^d}_{\text{Domestic Emissions to Yd}} + \underbrace{P^m Y^d}_{\text{Imported Emissions to Yd}} + \underbrace{(P^d + P^m)Y^x}_{\text{Domestic and imported Emissions to exports (VS)}}$$

Methodology

- **Domestic Balance of Factor Content (BDFC):**
  - Reassignment of the emissions between countries since an important share of the traded goods belongs to the global value chains of production (Peters *et al*., 2012; Andrew y Peters, 2013 ; Su and Ang, 2011).
  - **In our example:**

$$BDEE^{T\text{-}J\text{-}E\text{-}M} = (E^{EARTH}) - (E^{JUPITER} + E^{EUROPE} + E^{MOON})$$

Analysis by Rows / Columns

Producer / Consumer

$$WBDFC = E^E - E^M = \sum_{\substack{rst \\ r \neq s \neq t}}^{n} P^{rs}\hat{y}^{st} - \sum_{\substack{rst \\ r \neq s \neq t}}^{n} P^{rt}\hat{y}^{rs} = 0$$

  - **In the Literature…**
    - BDFC is similar to the EEBT, only considers the domestic emissions of the country considered, differentiating between final goods and imports according to the formulation of Kanemoto et al. (2012), but differs in that **it incorporates all stages of the production.**
    - BDFC **assigns the responsibility to the agent of the country of intermediate and final demand** and which buy and sell these goods (the same as in EEBT), whereas in the MRIO-B and RB the responsibility is assigned to the agents of final demand in those countries.

Methodology

- **Balance of avoided factor content (BAFC):**
  - Our tool to calculate the **Pollution Haven Hypothesis,** that occurs when the emissions linked to exports (EEX) by a country are larger than emissions avoided by imports (EAM).
  - If the rest of the world has the same pollution technology that Country 1 the expression of emissions avoided by imports is:

$$E^{AM} = \begin{pmatrix} f^1 & 0 & 0 \\ 0 & f^1 & 0 \\ 0 & 0 & f^1 \end{pmatrix} \begin{pmatrix} L^{11} & L^{12} & L^{13} \\ L^{21} & L^{22} & L^{23} \\ L^{31} & L^{32} & L^{33} \end{pmatrix} \begin{pmatrix} \hat{y}^{11} \\ \hat{y}^{21} \\ \hat{y}^{31} \end{pmatrix} = \begin{pmatrix} P^{*11}\hat{y}^{11} + P^{*12}\hat{y}^{21} + P^{*13}\hat{y}^{31} \\ P^{*21}\hat{y}^{11} + P^{*22}\hat{y}^{21} + P^{*23}\hat{y}^{31} \\ P^{*31}\hat{y}^{11} + P^{*32}\hat{y}^{21} + P^{*33}\hat{y}^{31} \end{pmatrix}$$

Avoided emissions by imports of country 1

$$E^{AM} = P^{1m}Y^d + (P^{1d} + P^{1m})Y^x$$

Imported Emissions avoided to Yd

Imported Emissions avoided to exports

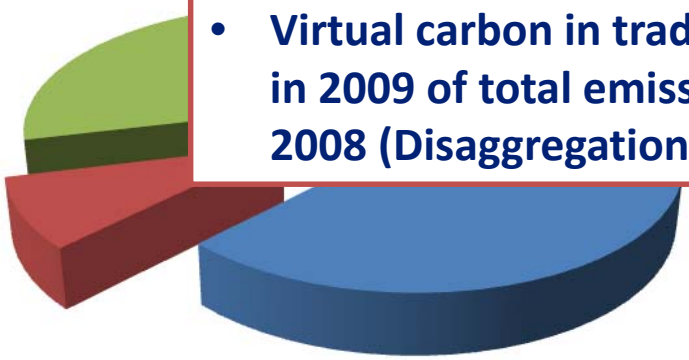
$$WBAFC = E^E - E^M = \sum_{\substack{rst, \\ r \neq s \neq t}}^{n} P^{rs}\hat{y}^{st} - \sum_{\substack{rst \\ r \neq s \neq t}}^{n} P^{st}\hat{y}^{tr}$$

If **WBAFC > 0 → PHH**

Results

Figure 1. Virtual carbon in world exports (7 regions, 2009, KtCO2)

- **Virtual carbon in trade represents a 17% in 1995 and a 23.5% in 2009 of total emissions → < Peters *et al.* (2011), 26% in 2008 (Disaggregation to 113 countries)**

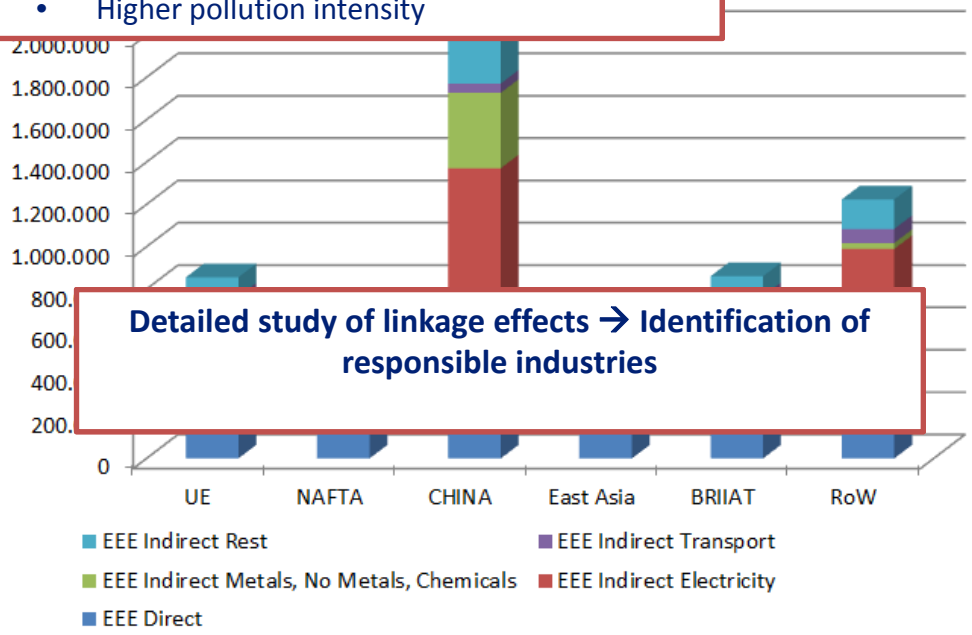


EEE Indirects EEE Directs Final Goods EEE Directs Inputs

- **Different pollution patterns**
  - Developed countries *vs* China

- **Direct emissions are more important in EU, NAFTA and EAST ASIA**
- **Indirect emissions associated with Electricity in CHINA explains ≈ 50% of EEE**

- Are more traded
- Higher pollution intensity



Detailed study of linkage effects → Identification of responsible industries

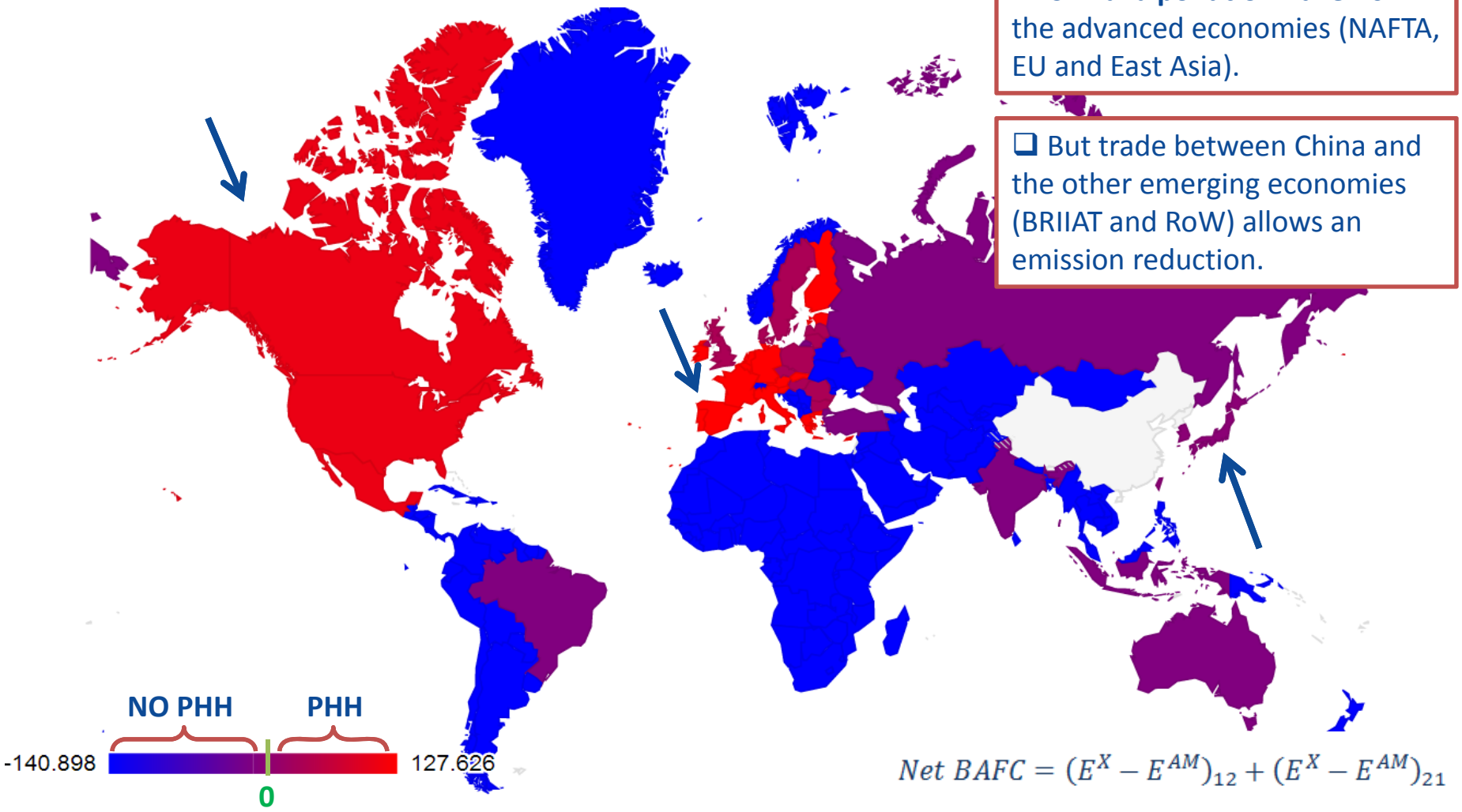
Figure 2. Direct *vs* indirect emissions in world exports by regions, 2009, $KtCO_2$

Results

- **BALANCE OF AVOIDED EMISSIONS by regions** (7 regions).
  - International trade has avoided **1.1 $GtCO_2$** in **2009**.
    - Represents a reduction of **18.1%** of embodied emissions in international trade or **4.4%** of global emissions associated with the production.
  - However, avoided emissions account for smaller shares in 2009 compared to 1995 (32.2% and 5.5% respectively).
    - Due to the significant growth of international trade between 1995 and 2009.
  - **Not all regions** bear the **same responsibility** for the abatement of emissions.
    - Six of the seven regions have managed to avoid emissions…
      - The only **exception** is **China**, where the effect of trade was an increase of emissions **by 1.12 $GtCO_2$.** → The gigatonne gap in China's carbon dioxide inventories (Guan *et al*., 2012)?

It is necessary to isolate the impact of trade volume → Net BAEs by regions

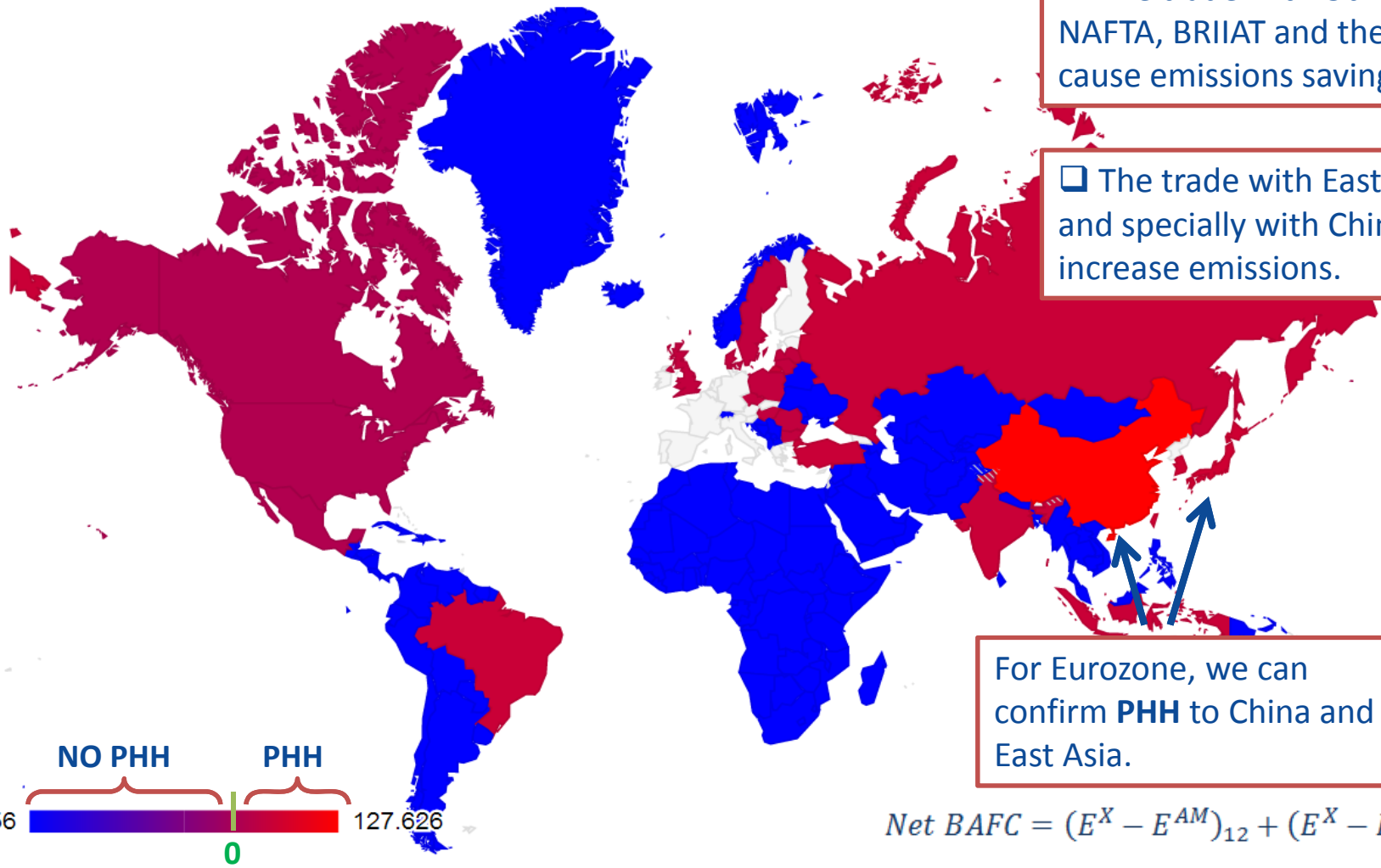
Net BAEs China, 2009



- China: a **pollution haven** of the advanced economies (NAFTA, EU and East Asia).
- But trade between China and the other emerging economies (BRIIAT and RoW) allows an emission reduction.

$$Net\ BAFC = (E^X - E^{AM})_{12} + (E^X - E^{AM})_{21}$$

Net BAEs Eurozone, 2009



- ❑ The trade with Other EU, NAFTA, BRIIAT and the RoW cause emissions savings.
- ❑ The trade with East Asia and specially with China increase emissions.

For Eurozone, we can confirm **PHH** to China and East Asia.

$$Net\ BAFC = (E^X - E^{AM})_{12} + (E^X - E^{AM})_{21}$$

Net BAEs RoW, 2009

❑ The 50% of emissions saving is explained by the developed countries trade with RoW.

❑ But… Is trade good for the environment?

- ❑ The RoW exports natural resource with a low VA and imports manufactured goods and capital goods, intensive in VA, perpetuates a pattern of trade which leads the RoW to specialising in resource extraction.
- ❑ The emissions which other regions avoid by trading with RoW can be largely explained by the imports of the sector "**mining and quarrying**", "**rubber and plastics**", "**basic metals and fabricated metals**"...
- ❑ These results show that *GVC accelerate the natural resources degradation far removed from the place of consumption*.

Lenzen *et al*. (2012) or **Karstensen *et al.* (2013)**

❑ The trade between RoW and the other regions is beneficial in emissions terms.

Results

❑ UNCERTAINTIES… The effects of region aggregation

- ❑ **The number of available regions / industries determines the volume of international trade** (Su and Ang, 2011; Su et al., 2011; Lenzen, 2012).
  - The distinction is made between the emissions which are generated within the borders of a region and those which are related to international trade.
- ❑ Our study is performed for 3 and 7 regions, which allows not only to confirm or disprove the validity of the PHH but also to study the effects of aggregation on the estimation results → **The level of aggregation affects the findings**:
  - The computations based on **3 regions** show that in 2009 the emission reduction represents **1.6% of the total**, whereas with **7 regions** the amount of avoided emissions reaches a **18.8% of the emissions embodied in trade** → **41 – 114??**
  - However, at both levels of aggregation the same tendency can be observed.
    - The relative importance of avoided emissions has decreased.
    - By regions, the trade of RoW with EU have managed to avoid emissions and the trade of China with the other two regions, RoW and EU, increase of global emissions.

Arteixo. INDITEX head office (*January 2013*)

Beijing. World's Factory (*January 2013*)

Where does all this lead us?

- **Maybe the increase of trade barriers with environmental arguments is not the solution.**

Widespread ENVIRONMENTAL POLICIES
Common but differentiated responsibility (Shared responsibility criterion)

- **Unilateral policies → Problems: Carbon Leakage → To China?**
- **Border Tax Adjustments to control carbon leakage:**
  - We should consider **Total Virtual Carbon** → LINKAGE EFFECTS.
- **International trade is reducing global emissions but at the expense of importing natural resources disproportionately from RoW.**
  - "The importance of examining **natural resources** & biodiversity loss instead of looking at the polluting producers in isolation."
  - "GVC accelerate habitat degradation far removed from the place of consumption."

THANK YOU
FOR YOUR ATTENTION

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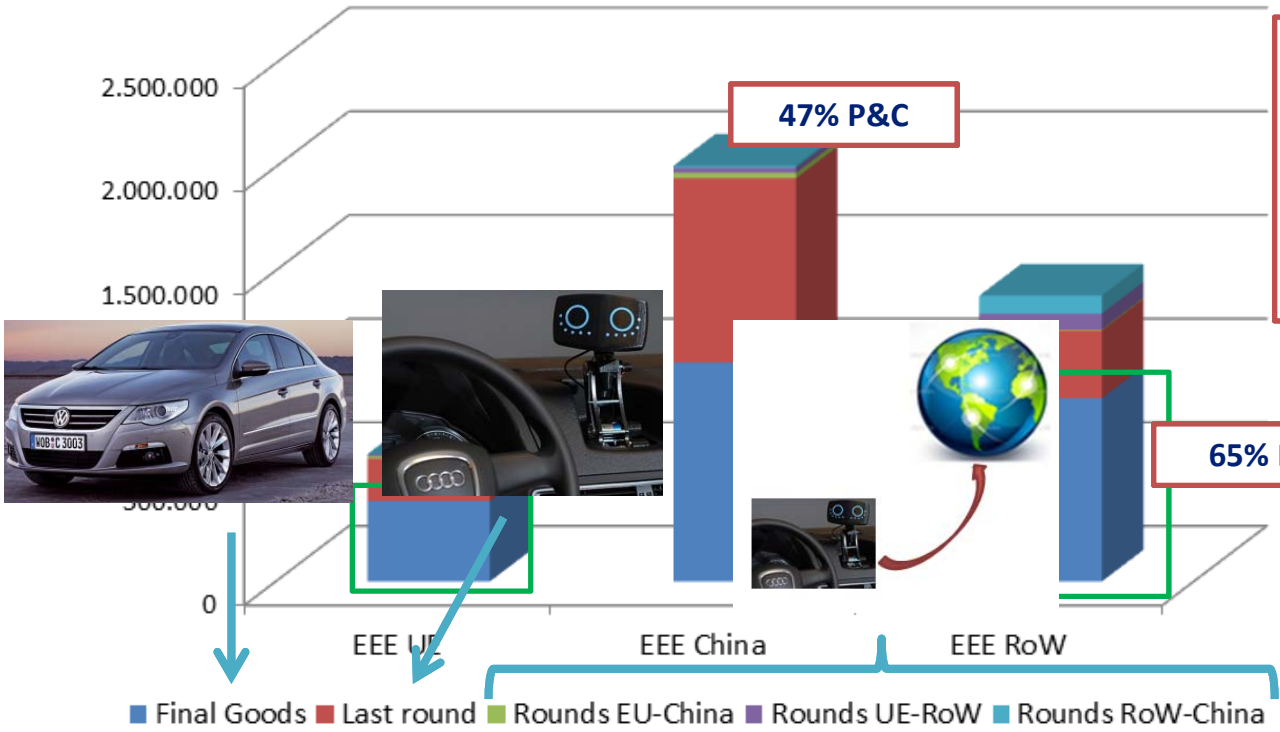
Results

NEXT STEP → What is the relevance of GVC?

Figure 3. Virtual carbon in exports: FINAL GOODS and GVC (3 regions, 2009, $KtCO_2$)



- **Main industries responsible as importers:**
  - *Electrical and Optical Equipment*
  - *Textiles*
  - *Machinery, Nec.*

Industries responsible in the international fragmentation of production