Indirect Pollution Haven Hypothesis in a Context of Global Value Chains

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OUTLINE

- Introduction
- Methodology
- Results
- Conclusions/Extensions
Introduction.

Focus on the international trade:
- International trade represents the 21% of GPD in 2007.
- It represents the 30% of the CO₂ emissions in the world in 2004.

2/3 of the international trade is intermediate goods → GLOBAL VALUE CHAINS

Is the GVC rise linked to the seek of comparative environmental advantages? Is there a reduction of the global emissions? How can we analyse it?

Tools:
Balance of Avoided Emissions to analyze the Pollution haven hypothesis (PHH): The lower trade barriers are set (higher trade), the higher emissions are produced?
Introduction.

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

- Emissions Balances (EB) and Responsibility Balances (RB)
  - Cadarso et al. (2010).
  - Davis et al. (2011).
  - Kanemoto (2012).

- Pollution Haven Hypothesis (PHH) – Balances of Avoided Emissions (BAE)
  - Dietzenbacher and Mukhopadhyay (2007).
  - Chen and Chen (2011).

- Global Value Chains (GVC)
  - Trefler and Zhu (2010).
  - Johnson and Noguera (2011).
Introduction.

Our contribution:

We develop a two-region and a MRIO model to analyse how the different stages of production and/or trade are responsible of the existence of PHH.

In one hand, our methodology allows us to:

1) Decompose the Balance of Avoided Emissions by type of traded good:
   
a) Balance of Avoided Emissions of final goods.
   
b) BAE of intermediate inputs required for the last international stage of production (attending the domestic final demand).
   
c) BAE of intermediate inputs required for all other international stages of production to attend the exported final demand.

Points b) and c) captures and measure the existence of Global Value Chains (GVC).

c) Captures the Hummels concept of Vertical Specialization.
In the other hand, our methodology allows us to:

2) Differentiate between initial, direct and indirect effects:

Who takes the delocalisation decision? → FIRMS. In global terms, the direct effects of the carbon leakages processes can be high, but it´s interesting to know if the indirect effects are even higher, to implement more accurate regulations.

SUMMARIZING:
IN THIS PAPER WE ISOLATE THE ROLE OF DIFFERENT COUNTRIES INVOLVED IN GVC, ANALYSING THEIR DIRECT OR TOTAL ENVIRONMENTAL IMPACT.

WE APPLY THIS MODEL TO THE TRADE BETWEEN SPAIN AND CHINA (2000-10)
Methodology (two regions).

Trade Balance (TB):

\[ TB = X_1 - M_1 = \left[ A_2^m \left( I - A_2^d \right)^{-1} \hat{y}_2^d + \hat{y}_2^m \right] - \left[ A_1^m \left( I - A_1^d \right)^{-1} \hat{y}_1^d + \hat{y}_1^m \right] \]

Trade Balance by type of good traded:

\[ TB = [\hat{y}_2^m - \hat{y}_1^m] + \left\{ \left[ L_2^m \hat{y}_2^r \right] - \left[ L_1^m \hat{y}_1^r \right] \right\} + \left\{ \left[ L_2^m \hat{y}_2^x \right] - \left[ L_1^m \hat{y}_1^x \right] \right\} \]

1. Final goods trade
   - Barbie dolls trade

2. Intermediate inputs trade. Last international stage.
   - Navigator embodied in a SEAT sold in Spain

3. Intermediate inputs trade. Rest of international stages.
   - Navigator embodied in a SEAT exported

Where: \( \hat{y}^d = \hat{y}^r + \hat{y}^x \)

\( L^m = A^m \left( I - A^d \right)^{-1} \)

Hummels Vertical Specialization
Methodology.

- **Bi-regional Balance of Domestic Emissions (BBDE):**

\[
BBDE = \varepsilon_1 X_1 - \varepsilon_2 M_1 = \varepsilon_1 \left[ L_2^m y_2^d + y_2^m \right] - \varepsilon_2 \left[ L_1^m y_1^d + y_1^m \right]
\]

- Negative balance (developed countries): they are importing pollution.
- Sign depends on: Result of the trade balance and emissions multipliers.
- With this methodology, the emissions derived from imports to export are not cancelled, not like in many other balances from literature.

- **BBDE by type of good traded:**

\[
BBDE = \varepsilon_1 y_2^m - \varepsilon_2 y_1^m + \varepsilon_1 \left[ L_2^m y_2^r \right] - \varepsilon_2 \left[ L_1^m y_1^r \right] + \varepsilon_1 \left[ L_2^m y_2^x \right] - \varepsilon_2 \left[ L_1^m y_1^x \right]
\]

1.- Final goods trade
2.- Intermediate inputs trade. Last international stage.
3.- Intermediate inputs trade. Rest of international stages.

Where: 
\[ \varepsilon = e(I - A)^{-1} \]

- \( e \) initial effects
- \( e \cdot A \) direct effects
- \( \varepsilon \) Total effects
Indirect Pollution Haven Hypothesis in a Context of Global Value Chains

Methodology.

- **Balance of Avoided Emissions (BAE) DTA:**
  \[ BAE = EEX - EAM = \varepsilon_1 X_1 - \varepsilon_1 M_1 \]

- **Bi-regional Balance of Avoided Emissions (BBAE):**
  \[ \sum BAE = (\varepsilon_1 X_1 + \varepsilon_2 X_2) - (\varepsilon_1 M_1 + \varepsilon_2 M_2) \]

  - Balance sign depends on:
    - Pollution intensities per country.
    - Trade structure → Similar to Comparative Advantage.

  - Limitations:
    - Right measure of GVC → Needed of MRIO models.
    - International freight transport → Cadarso et al. (2010).

Remember the differences:

\[ BBDE = \varepsilon_1 X_1 - \varepsilon_2 M_1 \]

If \( \sum BAE > 0 \)

Pollution Haven Hypothesis
Methodology.

BAE by type of good traded:

\[
\sum BAE = \left[ \epsilon_1 y_2^m - \epsilon_1 y_1^m + \epsilon_2 y_1^m - \epsilon_2 y_2^m \right] +
\]

1.- Avoided Emissions of final goods

\[
+ \left[ \epsilon_1 L_2^m y_2^r - \epsilon_1 L_1^m y_1^r + \epsilon_2 L_1^m y_1^r - \epsilon_2 L_2^m y_2^r \right] +
\]

2.- Avoided Emissions of intermediate inputs, last international stage.

\[
+ \left[ \epsilon_1 L_2^m y_2^{x_1} - \epsilon_1 L_1^m y_1^{x_2} + \epsilon_2 L_1^m y_1^{x_2} - \epsilon_2 L_2^m y_2^{x_2} \right] +
\]

3.i.- BAE of intermediate inputs, imports to export to Region 2.

\[
+ \left[ \epsilon_1 L_2^m y_2^{x_{2ROW}} - \epsilon_1 L_1^m y_1^{x_{1ROW}} + \epsilon_2 L_1^m y_1^{x_{1ROW}} - \epsilon_2 L_2^m y_2^{x_{2ROW}} \right] > 0
\]

3.ii.- BAE of intermediate inputs, imports to export to ROW

EXPORTS TO:

3.i REGION 2
3.ii ROW
Results.

Empirical analysis for Spain-China case.
Results (Empirical analysis for Spain-China case).

Data sources:

- Economic structure: Symmetric Input-Output Tables from Spain and China (OECD, 2005).
- Trade data by sector: Spain-China trade from Spanish Customs Department (2005).
- Chinese emissions data: Two steps:
  1) Calculation of emissions factor by type of energy good combusted (IPCC).

= Emissions Matrix by Sector.
Results (Empirical analysis for Spain-China case).

  - Trade deficit 2000 = 4.159 M€
  - Trade deficit 2010 = 14.880 M€

Negative balance of the Spain-China Trade Balance.

DEFICIT FOR ALL THE SECTORS
Results (Empirical analysis for Spain-China case).

- Bi-regional Balance of Domestic Emissions, Spain – China (ktCO₂):

- Year 2005: -61,200 ktCO₂.
- Year 2010: -71,600 ktCO₂.

RATIOS:

\[
\frac{Exports \ (M€)}{Imports \ (M€)} = \frac{1488}{13914} = 10\%
\]

\[
\frac{Emissions \times \ (ktCO₂)}{Emissions \ M \ (ktCO₂)} = \frac{672}{72219} \approx 1\%
\]

\[
\frac{SP–CH \ Emissions \ Deficit}{Total SP \ Emissions} \approx 20\%
\]
Results (Empirical analysis for Spain-China case).

Balance of Avoided Emissions for 2005:

Main results:
- Emissions Balance (2005) = -61,200 ktCO₂
- BAE (2005) = 29,958 ktCO₂ (49%). The absence of trade, would reduce the global emissions.
- The indirect effects are the main important (61%).
- The differentiation between type of goods is relevant.

TRADE STRUCTURE & POLLUTION INTENSITIES
## Results (Empirical analysis for Spain-China case).

- **Spain – China Emissions coefficients by sector (ktCO₂/M€):**

<table>
<thead>
<tr>
<th>Sector</th>
<th>SPAIN</th>
<th>CHINA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Power, gas and water</td>
<td>2.41</td>
<td>12.24</td>
</tr>
<tr>
<td>Manufacture of non-ferrous Metals</td>
<td>1.61</td>
<td>9.27</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
<td>1.07</td>
<td>3.07</td>
</tr>
<tr>
<td>Coke, Petroleum and Nuclear fuels</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>Transport, Storage and Post</td>
<td>0.27</td>
<td>1.16</td>
</tr>
<tr>
<td>Agriculture, forestry &amp; fishing</td>
<td>0.25</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Chemicals</strong></td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td><strong>Iron &amp; Steel</strong></td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Pulp, paper and publishing</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Manufacture of Transport Equipment</td>
<td></td>
<td>0.5</td>
</tr>
</tbody>
</table>

- **Note:** Compared to Spain, emissions in China are significantly higher in several sectors, with some factors up to 700 times higher.

- Electric Power, gas and water: 5 times Spanish factor
- Coke, Petroleum and Nuclear fuels: 14 times Spanish factor
- Rubber and plastic products: 700 times Spanish factor
- Iron & Steel: 14 times Spanish factor
- Mining and Quarrying: 2.5 times Spanish factor
- Transport, Storage and Post: 4.3 times Spanish factor
- Chemicals: 5 times Spanish factor
- Pulp, paper and publishing: 5 times Spanish factor
- Manufacture of Transport Equipment: 16 times Spanish factor
Results (Empirical analysis for Spain-China case).

- Initial, direct and indirect effect of the BAE by ROWS, 2005:

![Bar chart showing the initial, direct, and indirect effects of the BAE in various industries such as Electric Power, Gas and Water, Iron & steel, Coke, petroleum and nuclear, Chemicals, Rubber & plastics products, Textiles, and Transport, Storage and Post.]
Results (Empirical analysis for Spain-China case).

Balance of Avoided Emissions by COLUMNS, 2005:

- Textiles
- Construction
- Manufacture of Transport Equipment
- Machinery & equipment, nec
- Manufacturing nec; recycling
- Electrical machinery, nec

Graph showing emissions for various categories with different hypotheses (PHH 1, PHH 2, PHH 3i, PHH 3ii) compared against each other.
Conclusions.

Methodology contributions to BAE.
- BAE by type of good to capture GVC.
- Differentiation between initial, direct or indirect effects.

Empirical application bi-regional model:
- Main result: Relevant PHH (29958 ktCO₂).
  - Spanish-China trade increase global emissions.
  - There are high indirect effects, because of the coal intensive Chinese electricity mix.
  - The 57% of the PHH is GVC.
  - The rest of PHH, 43%, is due to final goods trade.
Limitations and Extensions:

- More years.
- Bi-regional models doesn’t capture all the GVC.  
  - We required a MRIO model to capture them.  
  The use of WIOD could be a solution.
- The Chinese CO$_2$ emissions data only includes the combustion of energy goods, and doesn’t include the emissions from industrial processes.  
  - We are under estimating the Chinese emissions results.

- Look for environmental policies implementations.  
  - BTA (double accounting).  
  - Eco-Labelling including international freight transport emissions.
THANK YOU FOR YOUR ATTENTION

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Methodology.

**MRIO model:**

\[
\begin{bmatrix}
F^{11} & F^{12} \\
F^{21} & F^{22}
\end{bmatrix}
= 
\begin{bmatrix}
P^{11} & P^{12} \\
P^{21} & P^{22}
\end{bmatrix}
\begin{bmatrix}
y^{11} & 0 \\
0 & y^{22}
\end{bmatrix}
+ 
\begin{bmatrix}
P^{11} & P^{12} \\
P^{21} & P^{22}
\end{bmatrix}
\begin{bmatrix}
y^{21} & 0 \\
0 & y^{22}
\end{bmatrix}
= 
\begin{bmatrix}
P^{11}y^{11} & P^{12}y^{22} \\
P^{21}y^{11} & P^{22}y^{22}
\end{bmatrix}
+ 
\begin{bmatrix}
P^{12}y^{21} & P^{11}y^{12} \\
P^{22}y^{21} & P^{21}y^{12}
\end{bmatrix}
\]

**MRIO Balance Domestic Emissions (BBDE):**

\[
BEDM^1 = EEXN^1 - EMMN^1 = 
\left(\frac{P^{11}\hat{y}^{12} + P^{12}\hat{y}^{22} + P^{12}\hat{y}^{21}}{8.1}\right) - \left(\frac{P^{21}\hat{y}^{12} + P^{21}\hat{y}^{11} + P^{22}\hat{y}^{21}}{8.2}\right) = \left(\frac{P^{11}\hat{y}^{12} - P^{22}\hat{y}^{21}}{8.3}\right) + 
\left(\frac{P^{12}\hat{y}^{22} - P^{21}\hat{y}^{11}}{8.4}\right) + \left(\frac{P^{12}\hat{y}^{21} - P^{21}\hat{y}^{12}}{8.5}\right)
\]
Results (Empirical analysis for Spain-China case).

Initial, direct and indirect effect of the BAE by COLUMNS, 2005:

- **PHH indirect**
- **PHH initial**
- **PHH direct**