Building Global Physical Input-Output Tables for Iron and Steel in a Virtual Laboratory

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MFA model of the global steel sector

(Cullen et al. 2012)
Iron & steel metallurgy basics

Ironmaking

- Air + O2 (1350)
- Pellets/Sinter/Ore (1600)
- Coke + flux (660)

Steelmaking

Oxygen Blown Furnace
- Pig Iron
- Scrap: 10-25%

Electric Arc Furnace
- Mostly Sponge Iron
- Scrap: Up to 100%

Source: Steel Manual 2019
Step 1 (MFA): From extraction to fabrication

1. Vehicles
2. Ind. Machinery
3. Metal Goods
4. Construction

Flow of commodities

System boundary

Transformation nodes

Distribution nodes

Material balances from metallurgy literature

Trade accounts from UN COMTRADE

End-use shares (Cullen 2012)

Dynamic MFA results (Pauliuk 2013)

Production values & yield factors from World Steel Association

(Adapted from Pauliuk et al. 2015)
Step 2 (hybrid IO):
From manufacturing to end-use

„Waste IO approach“ → Synthesize a physical IO table from a monetary IO table!
(Nakamura et al. 2007)

1. Filter matrix to remove non-physical flows.
   → Calculate Inverse (L)
   → Calculate new gross production vector (x)
   → Allocate output of steel sector to final use

2. Yield factors → scrap flows from manufacturing

**EXIOBASE MRIO**: 1995-2016, 44 countries + 5 RoW, 200 products, 163 industries
Linking material flow & hybrid IO model

Graph View

Status Quo: 34 countries + RoW, 22 iron-containing products

Tabular View
General structure of physical supply-use tables

Two region example SUT with 3 industries & 4 products
Root classification

- 244 regions, 76 processes, 266 products
- 10 final demand categories
- 13 primary inputs

Constraint data feeds

- Raw data: IRP/MFA, WorldSteel, COMTRADE, dynamic MFA results for EoL Scrap
- Process descriptions: material balances & yield factors
- End-use shares

Initial Estimate

- 34 regions + RoW, 20 industries, 22 products
- Hybrid IO with EXIOBASE: from manufacturing to end-use!
- IEA energy data for gap filling
Integrated set of material flow indicators (2008)

Australia: 15.5 tons/head
Sweden: 3 tons/head
Material footprint of nations
PIOLab vs. EXIOBASE (2014)

Tons of iron ore per capita

PIOLab
EXIOBASE MRIO

Country: KR, NO, CN, AU, JP, DE, SE, CA, CH, AT, CZ, NL, US, SK, FI, SI, IT, FR, TR, GB, PL, RU, LT, GR, ES, PT, MX, HU, BG, RO, BR, HR, IN, ID
First results for 2008:
Raw data vs. PIOLab result

Iron ore extraction
- IRP MFA data
- PIOLab

End-of-life Scrap
- Pauliuk results
- PIOLab
Next steps and outlook

1. Initial Estimate
   - Increase number of countries to 44 and 5 RoW regions
   - Disaggregate finished steel products?

2. Constraint data feeds
   - Ratio constraints to better incorporate material balances

2020/21/22

- PIOTs for bauxite, copper and other metals
- Sub-nation PIOTs for hot-spot countries

How to get robust initial estimate for sub-national trade?
Outlook: Sub-national PIOTs for hot-spot regions

Iron ore extraction
Australia 2017
(100 km grid)