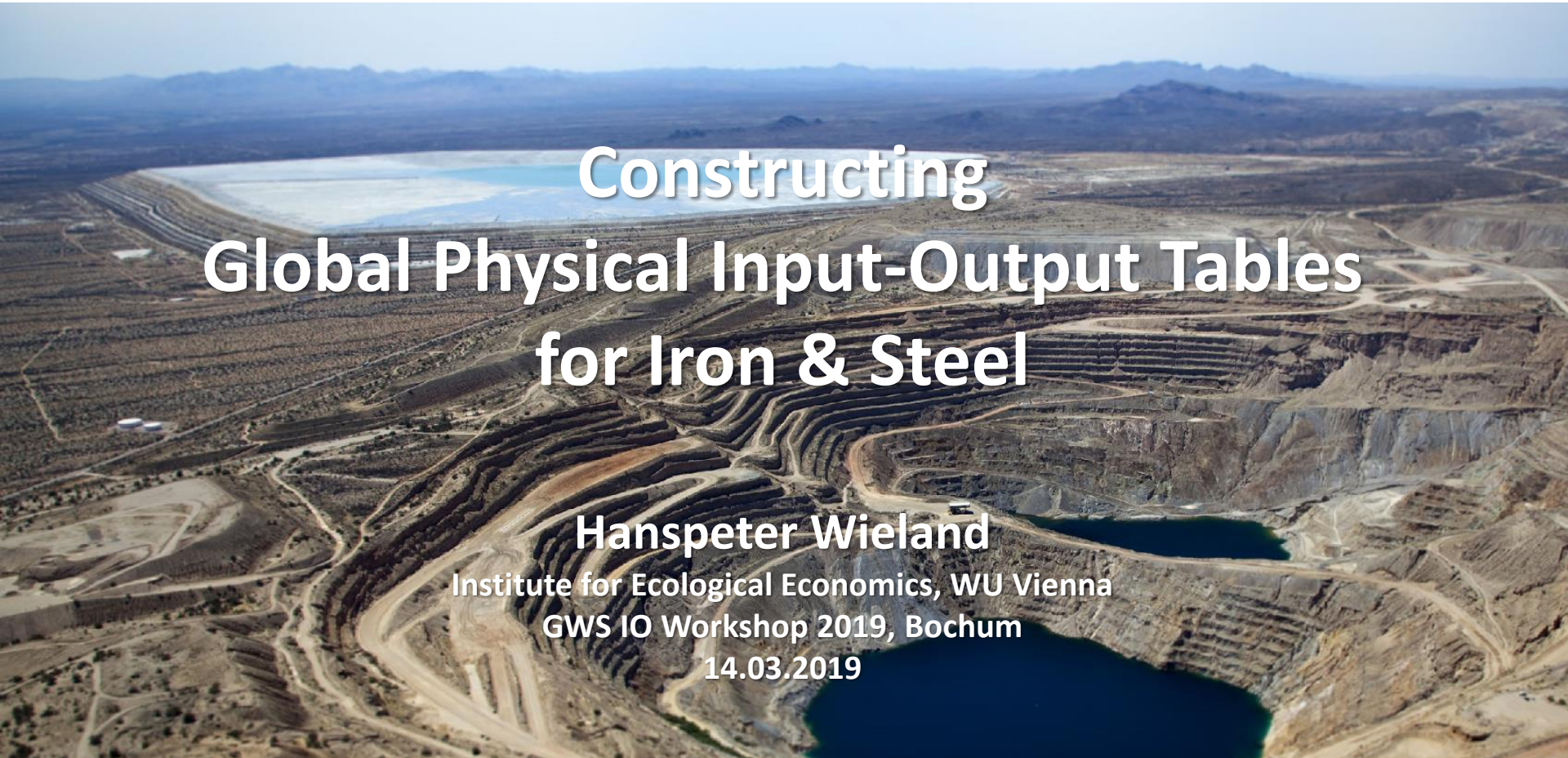

Constructing Global Physical Input-Output Tables for Iron & Steel

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GWS IO Workshop 2019, Bochum

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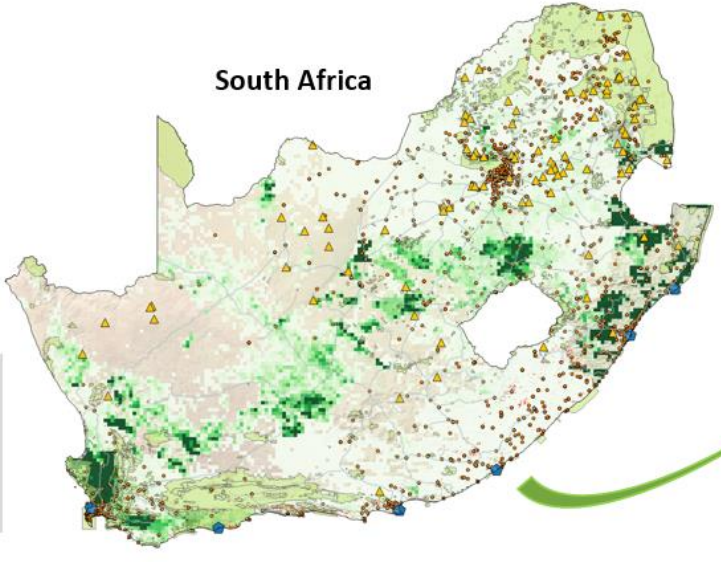
Content

- Introduction
- Modelling Framework
- First Pilot Results
- Outlook

Starting point: ERC-FINEPRINT

Work Stream 3:

Fine-scale material footprint and related impacts



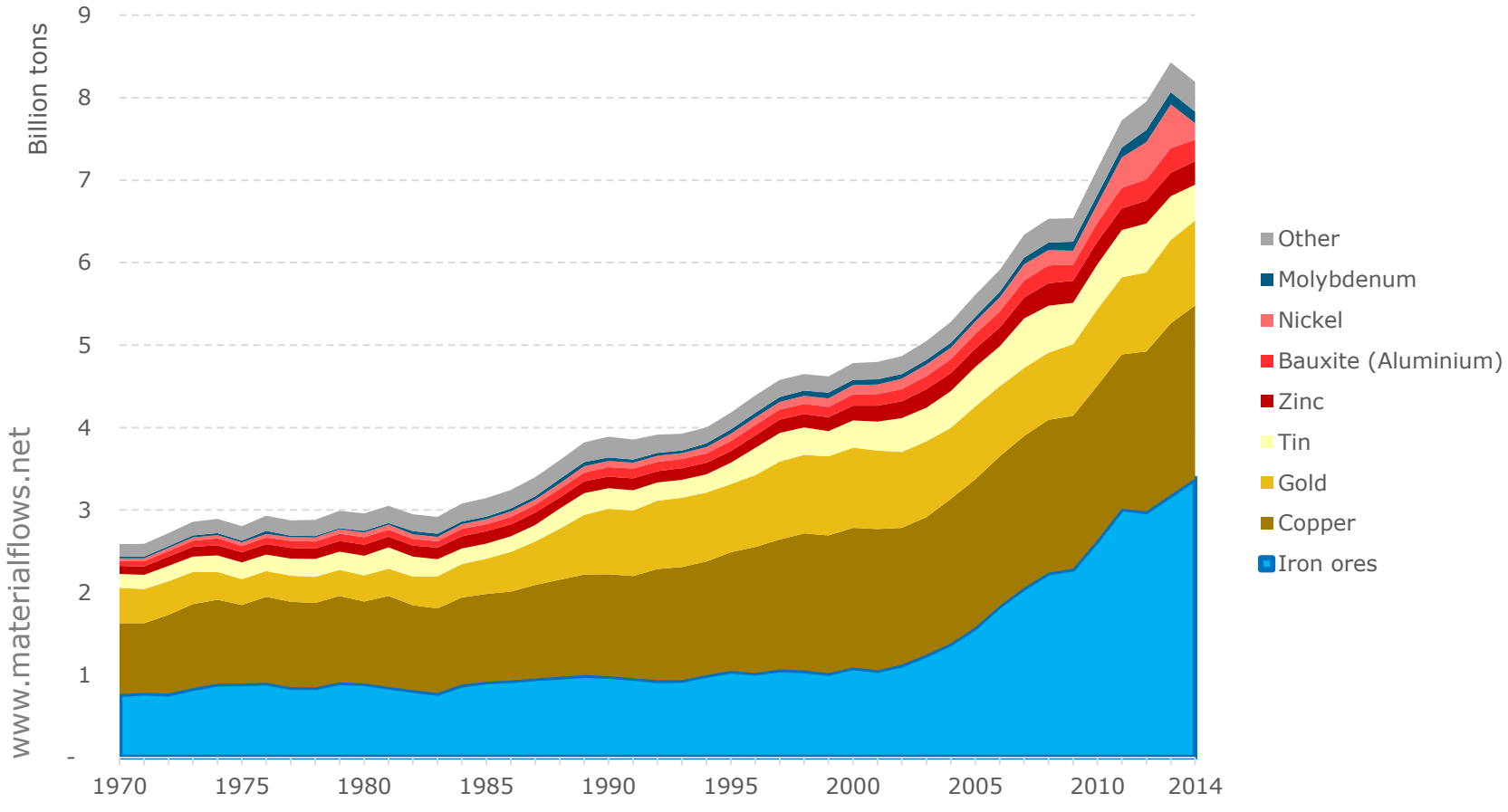
Work Stream 2:

Spatially explicit, multi-regional material flow model

Work Stream 1:

Spatial distribution of global raw material extraction and impacts

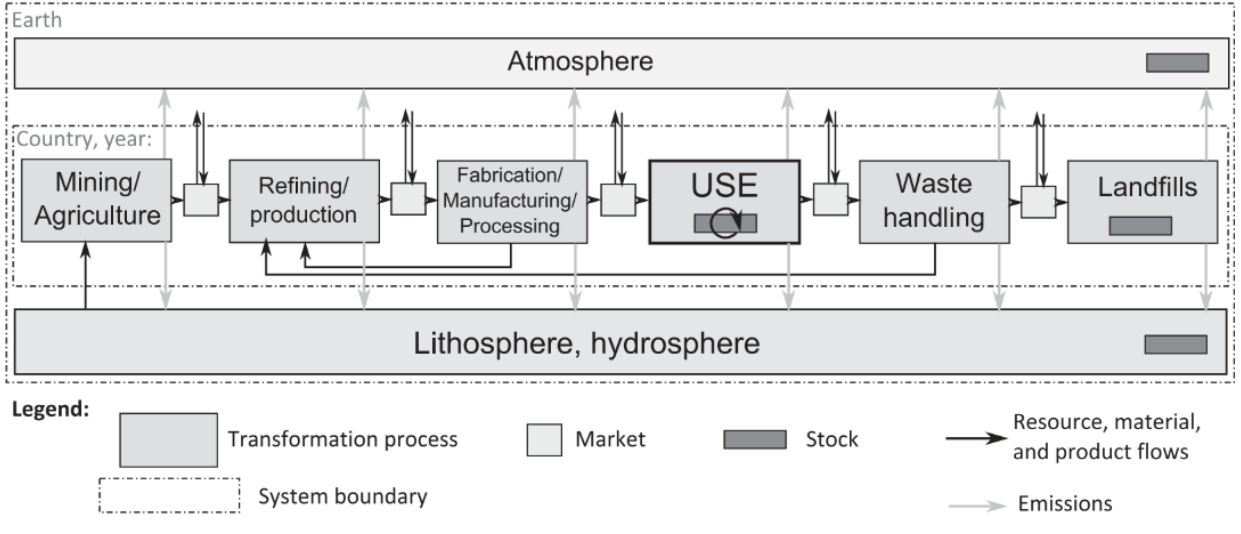
Global crude metal ore extraction



Socioeconomic metabolism (SM)
A graph visualization

a. Comprises All biophysical **transformation/distribution processes/flows**, controlled by humans.
b. Constitutes the self-reproduction/evolution of the **biophysical structures (BS) of human society** ('in use stocks').

SM & **BS** together form the **biophysical basis of society**!



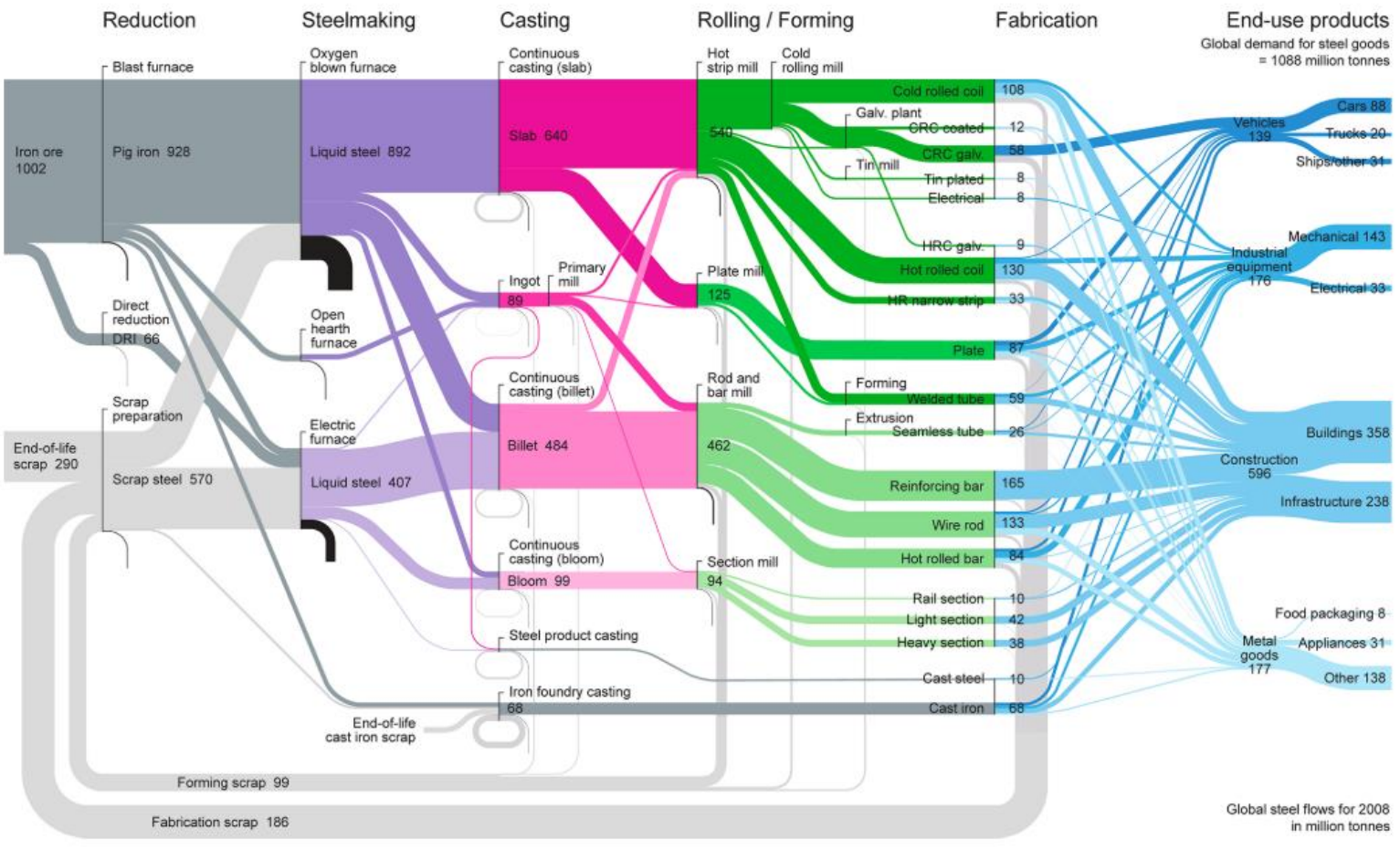
(Pauliuk & Hertwich 2015, Pauliuk et al. 2015)

„Shortcomings“ of MIOTs for assessing physical supply chains

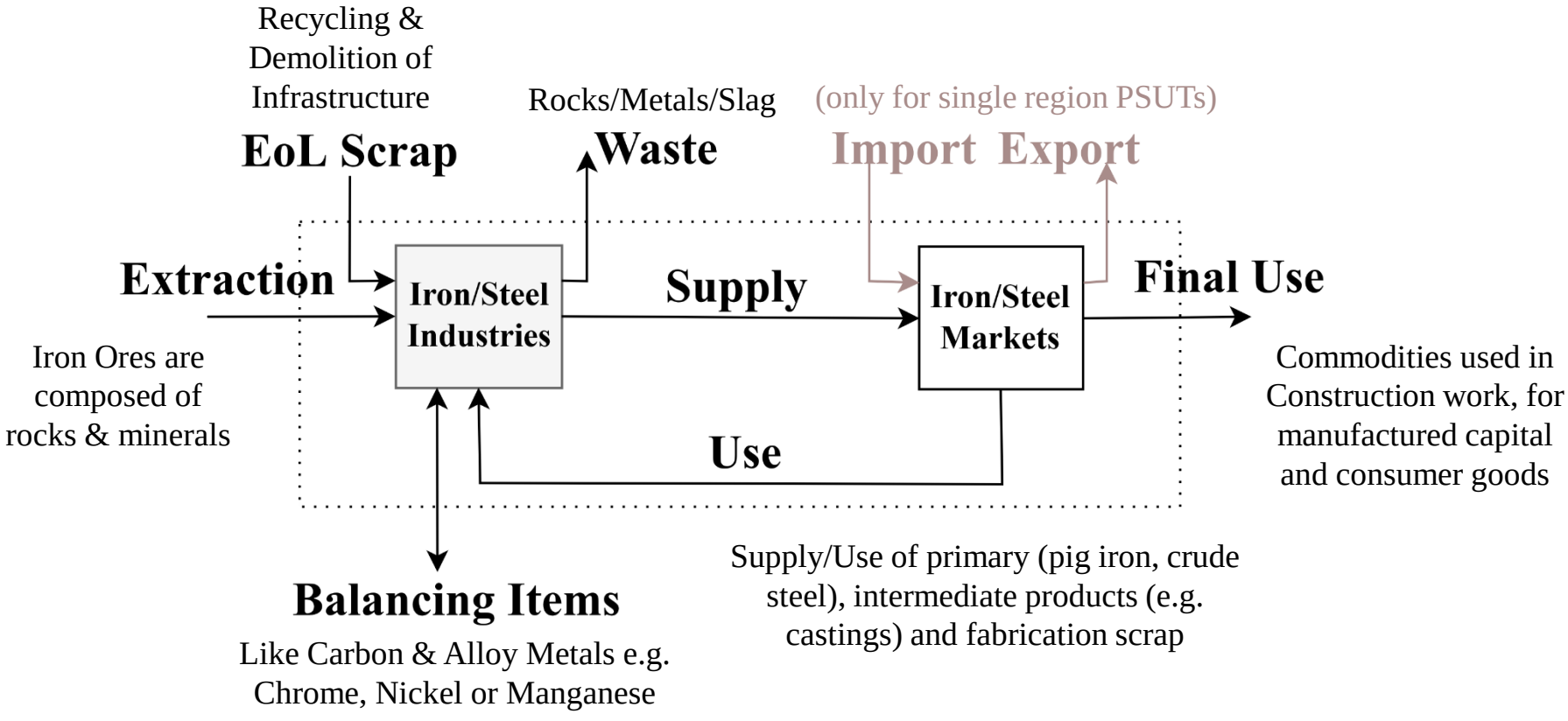
1. First processing steps are highly aggregated in monetary IOTs
2. Assume proportionality between physical and monetary flows
3. Low prices for bulk materials adds uncertainty
4. Assume that materials and money always (!) flow in opposing direction
5. MIOTs do not include non-market flows.
6. Treat capital formation as final demand: Endogenization?

Example study: (Cullen et al. 2012)

Material flow analysis (MFA) of steel



From Extraction to Fabrication
using physical supply-use tables



From manufacturing to final demand

Waste IO-MFA approach and MRIO

How to synthesize a „PIOT“ from a MIOT:

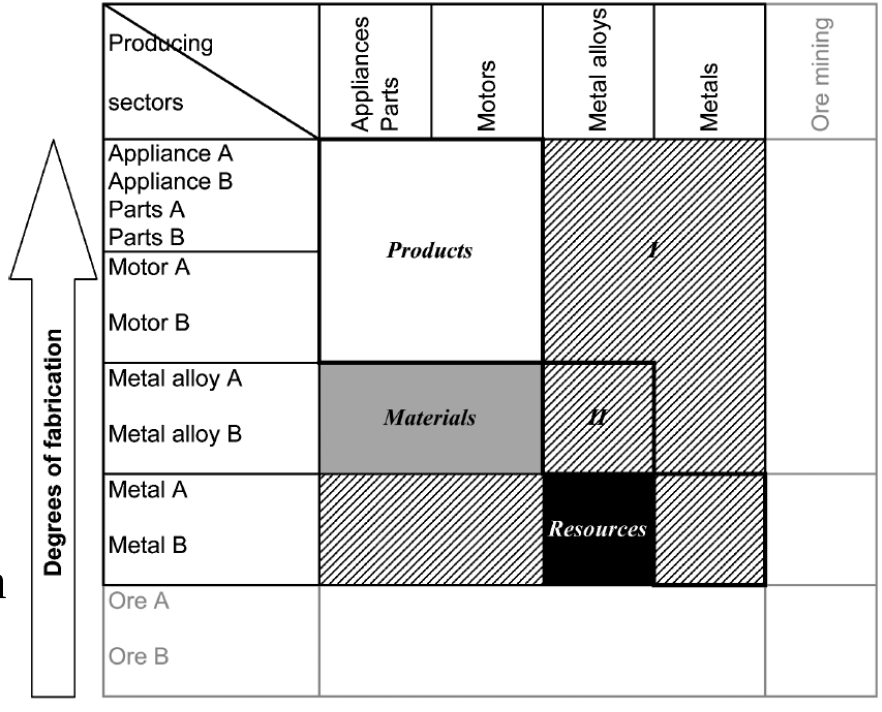
1. Filter matrix removes non-physical flows.

→ Apply power-series if necessary (L)

→ Calculate new gross production vector (x)

→ Allocate phyiscal flows to final demand

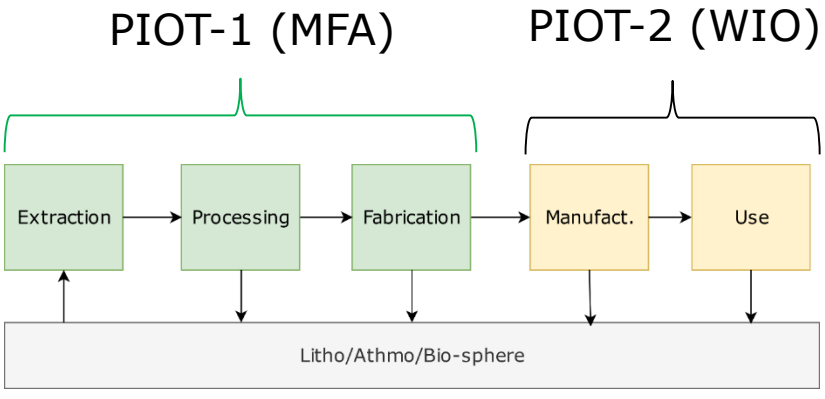
2. Yield matrix is used to model **scrap flows** in manufacturing



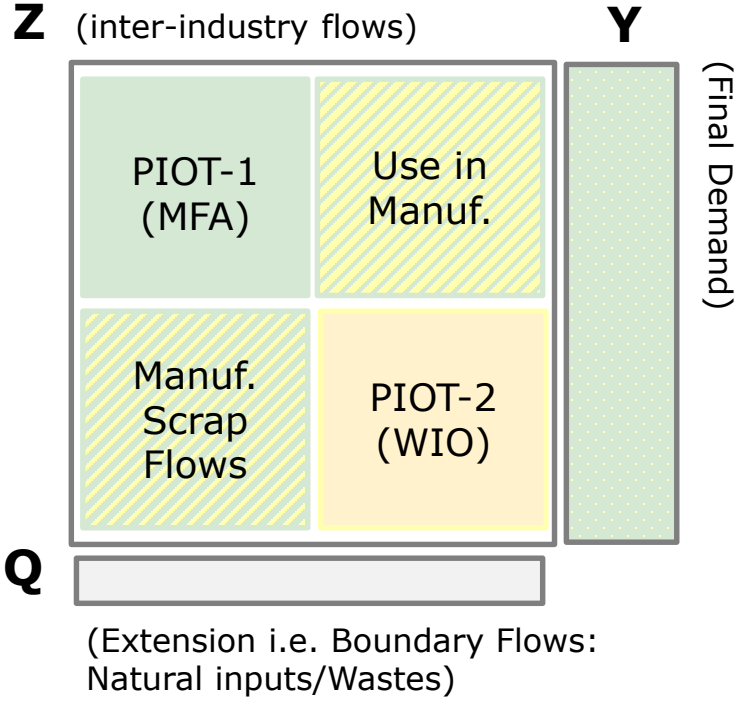
(Nakamura 2007)

From extraction to final demand
Linking the two PIOTs

Graph View



Tabular View



Global Physical Supply of Iron and Steel (2015)

fineprint

Flows-by-Processes (27x16)

UNIT: Mega Tons

Flow-by-Process Supply Table	Internal														Boundary	
	Mining	Beneficiation	Blast Furnace	Direct Reduction	Oxygen Blown Converter	Electric Furnaces	Open Hearth Furnaces	CC Slab	CC Billet & Bloom	Ingot Casting	Flat Rolling and Fabrication	Long Rolling and Fabrication	Strip Rolling and Fabrication	Scrap Preparation	From the Environment	From in-use stocks
Iron Ore	2 030	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Refined Ore	-	1 246	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pig Iron	-	-	1 158	76	-	-	-	-	-	-	-	-	-	-	-	-
Crude Steel	-	-	-	-	1 205	404	7	-	-	-	-	-	-	-	-	-
Slab	-	-	-	-	-	-	-	735	-	-	-	-	-	-	-	-
Billet & Bloom	-	-	-	-	-	-	-	-	814	-	-	-	-	-	-	-
Ingot	-	-	-	-	-	-	-	-	-	56	-	-	-	-	-	-
Hot Rolled Coil-Sheet-Strip	-	-	-	-	-	-	-	-	-	-	360	-	-	-	-	-
Hot Rolled Plate	-	-	-	-	-	-	-	-	-	-	251	-	-	-	-	-
Railway Track Material	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-
Heavy Sections	-	-	-	-	-	-	-	-	-	-	-	52	-	-	-	-
Light Sections	-	-	-	-	-	-	-	-	-	-	-	64	-	-	-	-
Concrete Reinforcing Bars	-	-	-	-	-	-	-	-	-	-	-	273	-	-	-	-
Wire Rod	-	-	-	-	-	-	-	-	-	-	-	198	-	-	-	-
Hot Rolled Bars other than CRB	-	-	-	-	-	-	-	-	-	-	-	137	-	-	-	-
Seamless Tubes	-	-	-	-	-	-	-	-	-	-	-	40	-	-	-	-
Welded Tubes	-	-	-	-	-	-	-	-	-	-	-	-	99	-	-	-
Tinmill Products	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
Electrical Sheet and Strip	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
Non-metal Coated/Sheet/Strip	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
Other Metal Coated Sheet/Strip	-	-	-	-	-	-	-	-	-	-	-	-	122	-	-	-
Fabrication and Forming Scrap	-	-	-	-	-	-	-	-	-	-	97	123	13	-	-	-
Scrap Steel	-	-	-	-	-	-	-	-	-	-	-	-	-	603	-	-
Natural inputs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2 030	-
End of Life Scrap	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	376
Waste Metal	-	-	12	1	164	55	1	6	6	0	-	-	-	6	-	-
Waste Rock	-	784	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Global Physical Use of Iron and Steel (2015)

fineprint

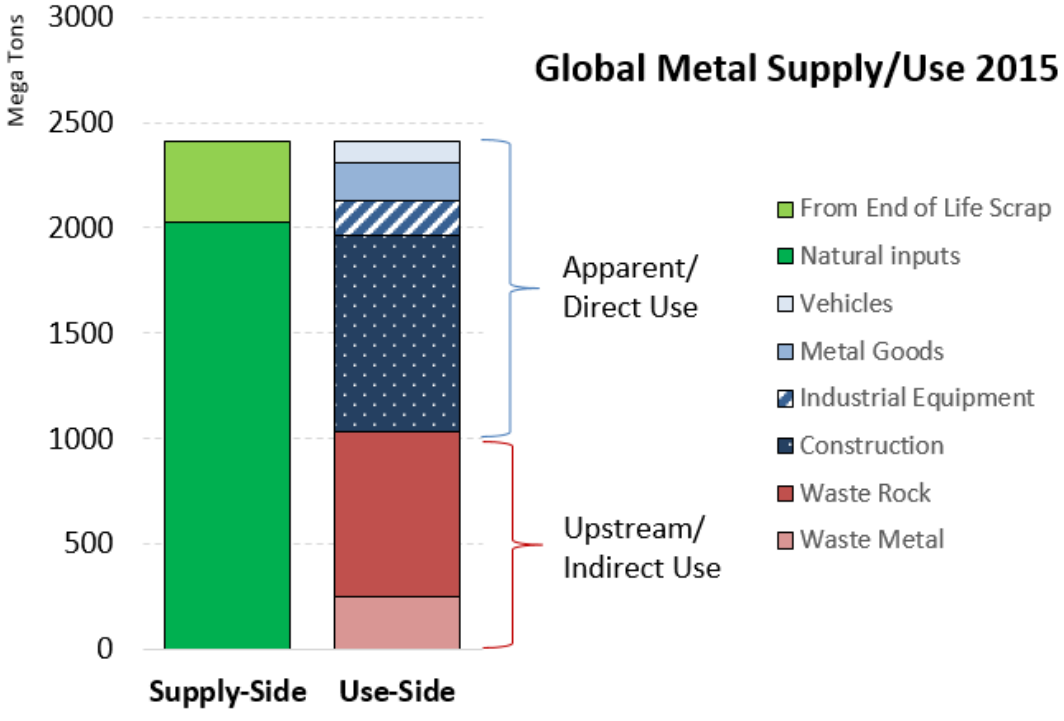
Flows-by-Processes (27x19)

UNIT: Mega Tons

Flow-by-Process Use Table	Internal														Final Use/Boundary				
	Mining	Beneficiation	Blast Furnace	Direct Reduction	Oxygen Blown Converter	Electric Furnaces	Open Hearth Furnaces	CC Slab	CC Billet & Bloom	Ingot Casting	Flat Rolling and Fabrication	Long Rolling and Fabrication	Strip Rolling and Fabrication	Scrap Preparation	Construction	Industrial Equipment	Vehicles	Metal Goods	Flows to the Environment
Iron Ore	-	2 030	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Refined Ore	-	-	1 170	77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pig Iron	-	-	-	-	1 096	130	8	-	-	-	-	-	-	-	-	-	-	-	-
Crude Steel	-	-	-	-	-	-	-	741	820	56	-	-	-	-	-	-	-	-	-
Slab	-	-	-	-	-	-	-	-	-	-	650	84	-	-	-	-	-	-	-
Billet & Bloom	-	-	-	-	-	-	-	-	-	-	57	757	-	-	-	-	-	-	-
Ingot	-	-	-	-	-	-	-	-	-	-	-	56	-	-	-	-	-	-	-
Hot Rolled Coil-Sheet-Strip	-	-	-	-	-	-	-	-	-	-	-	-	259	-	101	-	-	-	-
Hot Rolled Plate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	48	50	53	-
Railway Track Material	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	1	-	-	-
Heavy Sections	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52	-	-	-	-
Light Sections	-	-	-	-	-	-	-	-	-	-	-	-	-	-	64	-	-	-	-
Concrete Reinforcing Bars	-	-	-	-	-	-	-	-	-	-	-	-	-	-	273	-	-	-	-
Wire Rod	-	-	-	-	-	-	-	-	-	-	-	-	-	-	115	12	15	57	-
Hot Rolled Bars other than CRB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	59	24	47	-
Seamless Tubes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	6	9	-	-
Welded Tubes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62	34	2	2	-
Tinmill Products	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
Electrical Sheet and Strip	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
Non-metal Coated/Sheet/Strip	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
Other Metal Coated Sheet/Strip	-	-	-	-	-	-	-	-	-	-	-	-	-	-	122	-	-	-	-
Fabrication and Forming Scrap	-	-	-	-	-	-	-	-	-	-	-	-	-	233	-	-	-	-	-
Scrap Steel	-	-	-	-	274	329	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural inputs	2 030	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
End of Life Scrap	-	-	-	-	-	-	-	-	-	-	-	-	-	376	-	-	-	-	-
Waste Metal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	252
Waste Rock	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	784

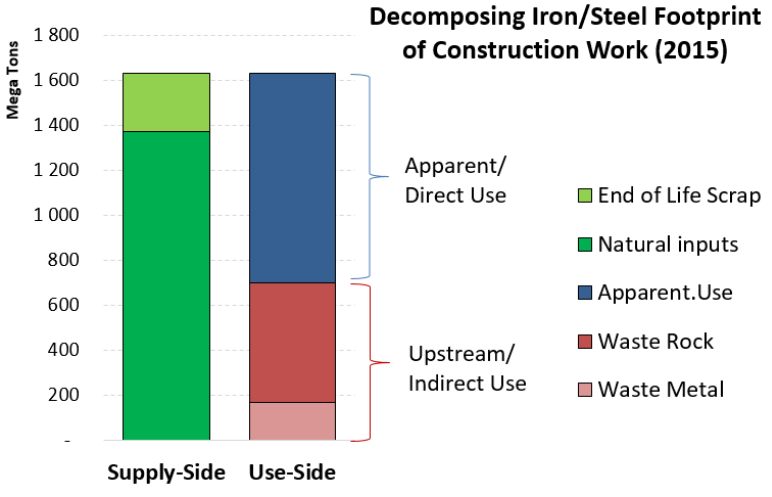
First Results of Global Pilot PIOT-1

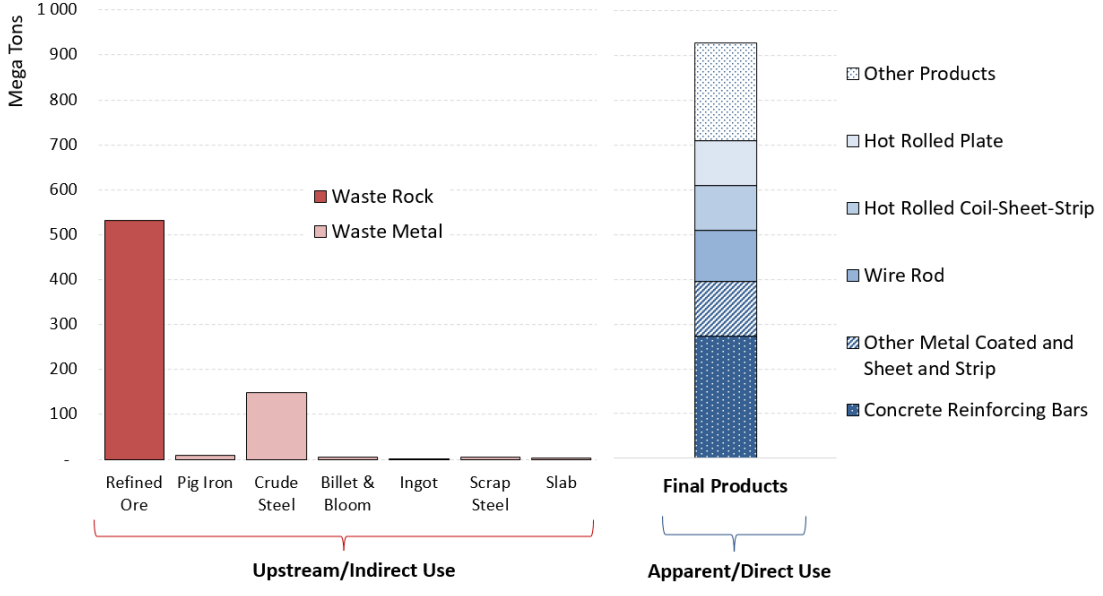
From Extraction to Fabrication (Iron & Steel)



First Results of Global Pilot PIOT-1

Iron & Steel Footprint of Construction





Outlook: Global PIOTs

- **Hybrid IOT to track economic use of manufactured capital**!
  - Endogenization of capital
  - Allocating means of production to non-metal industries

- **High detail metal PIOT for major metals** (iron, aluminum, copper,…)
- **„PIOT light" for other metals** (for example rare earths or alloying metals)

„Dreams of the future":
Integrated global physical IO tables covering flows of…

Biomass (FABIO)
Metals (FINEPRINT)
Energy (MF-GLOBE)

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