Corporate carbon accounting

Purpose, feasibility and convergence

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We have just seen –previous presentation– how footprints can be calculated at macro level, using I/O techniques.

We now need to get footprints at entity and product levels. Ideally, a Leontief matrix at such detailed level would be required, a sort of Big Brother matrix.

Hopefully, we don't need one. That's what corporate carbon accounting is all about.

1. **The two tenets of carbon accounting**
2. **Some reminders on I/O analysis**
3. **Estimation and convergence**

In case you missed it…

Direct emissions:
(scope 1)

emitted at plant/site level (transport, heating, etc.). At times, in the very process of production: cement, livestock farming…

Indirect emissions:
(scope 2 and 3 upstream)

emitted "upstream", at suppliers' level

Footprint

direct + indirect emissions

Indirect emissions shouldn't be omitted in carbon accounting:

(in tons of CO_2)	Direct emissions	Indirect emissions
Project A	500	700
Project B	400	1.000

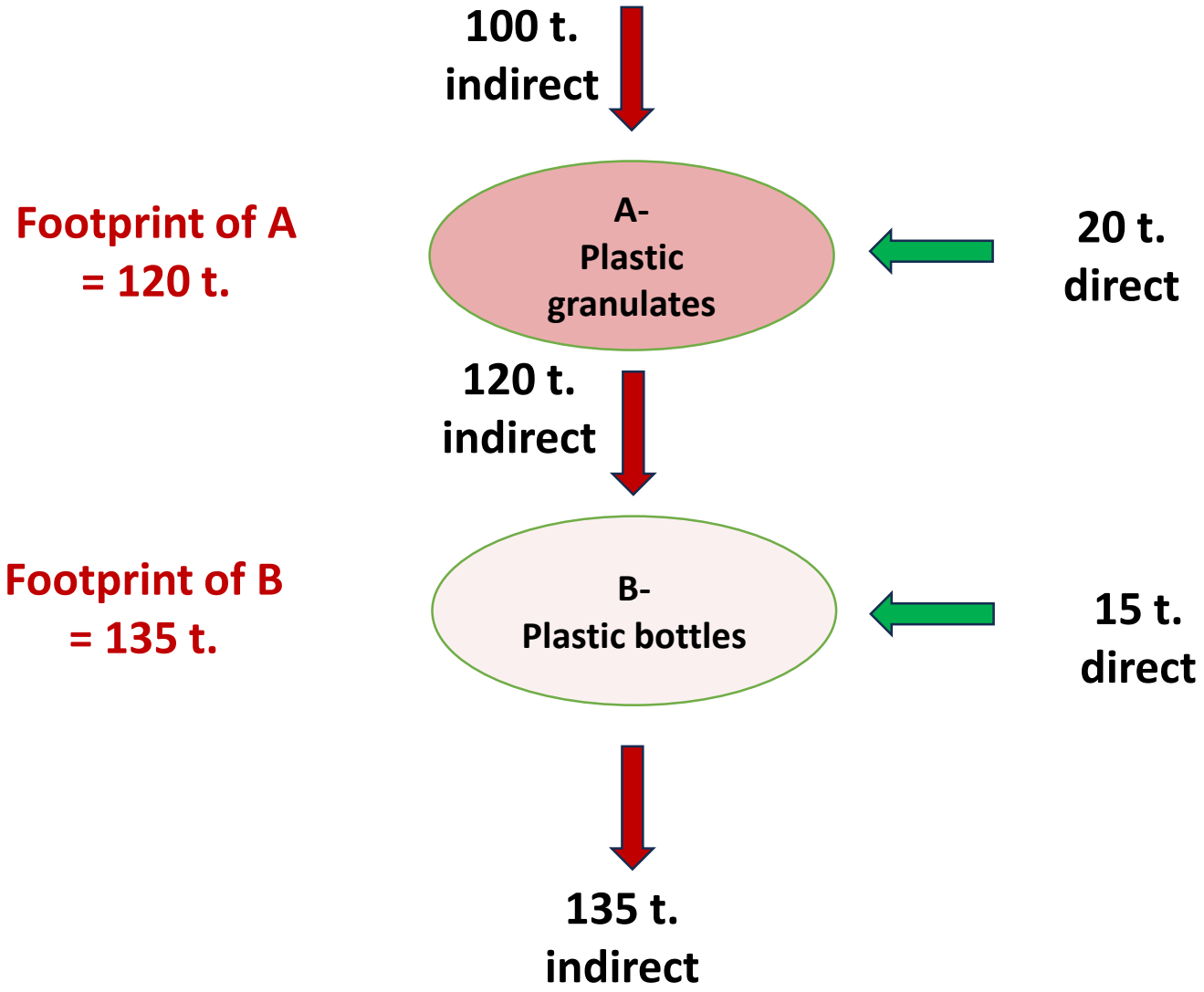
?

Which project do you choose?

Obviously, the one that doesn't omit indirect emissions.

Tenet #1: Micro perspective.

The need to account at company level



Carbon is added step by step in the value chain

incoming carbons : 135 t.

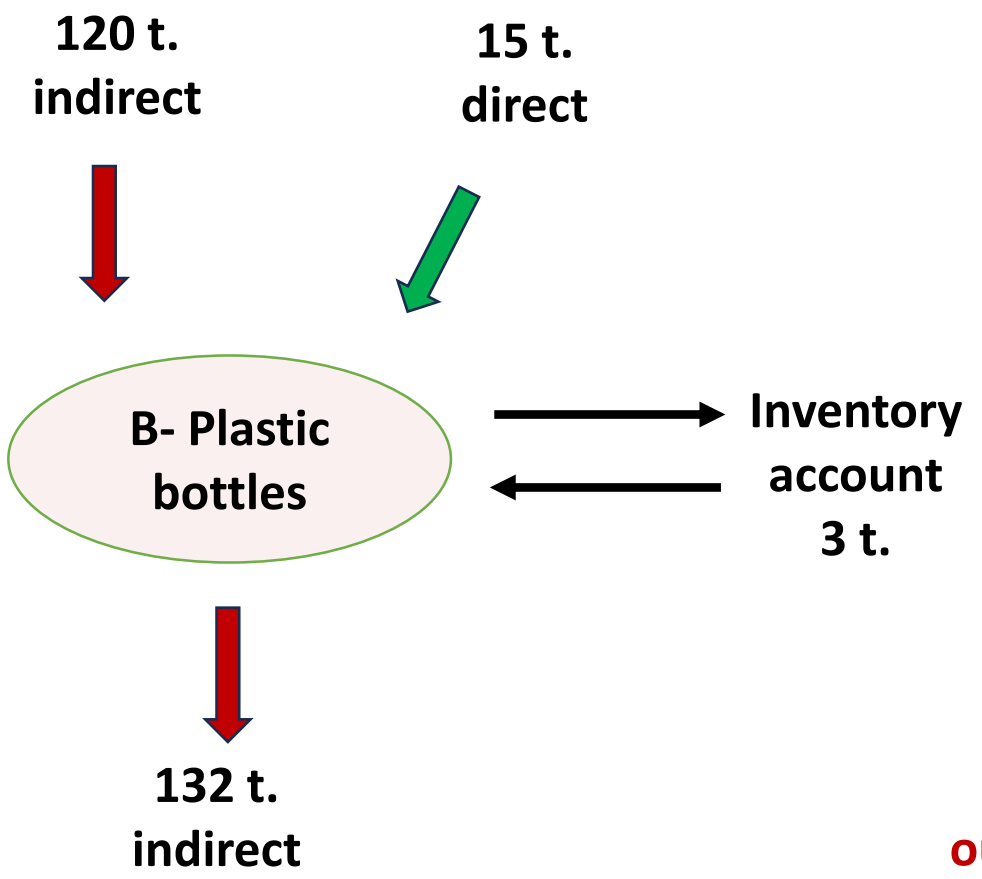
=

outgoing carbons : 135 t.

By the way, very similar to the cascading of the VAT.

Here, direct emissions are *added carbon*, not *added value*.

The key accounting balance



Footprint of B
= 132 t.

Due to accounting time lags, inventories, investment goods…, the carbon flows do enter the balance sheet for a moment…

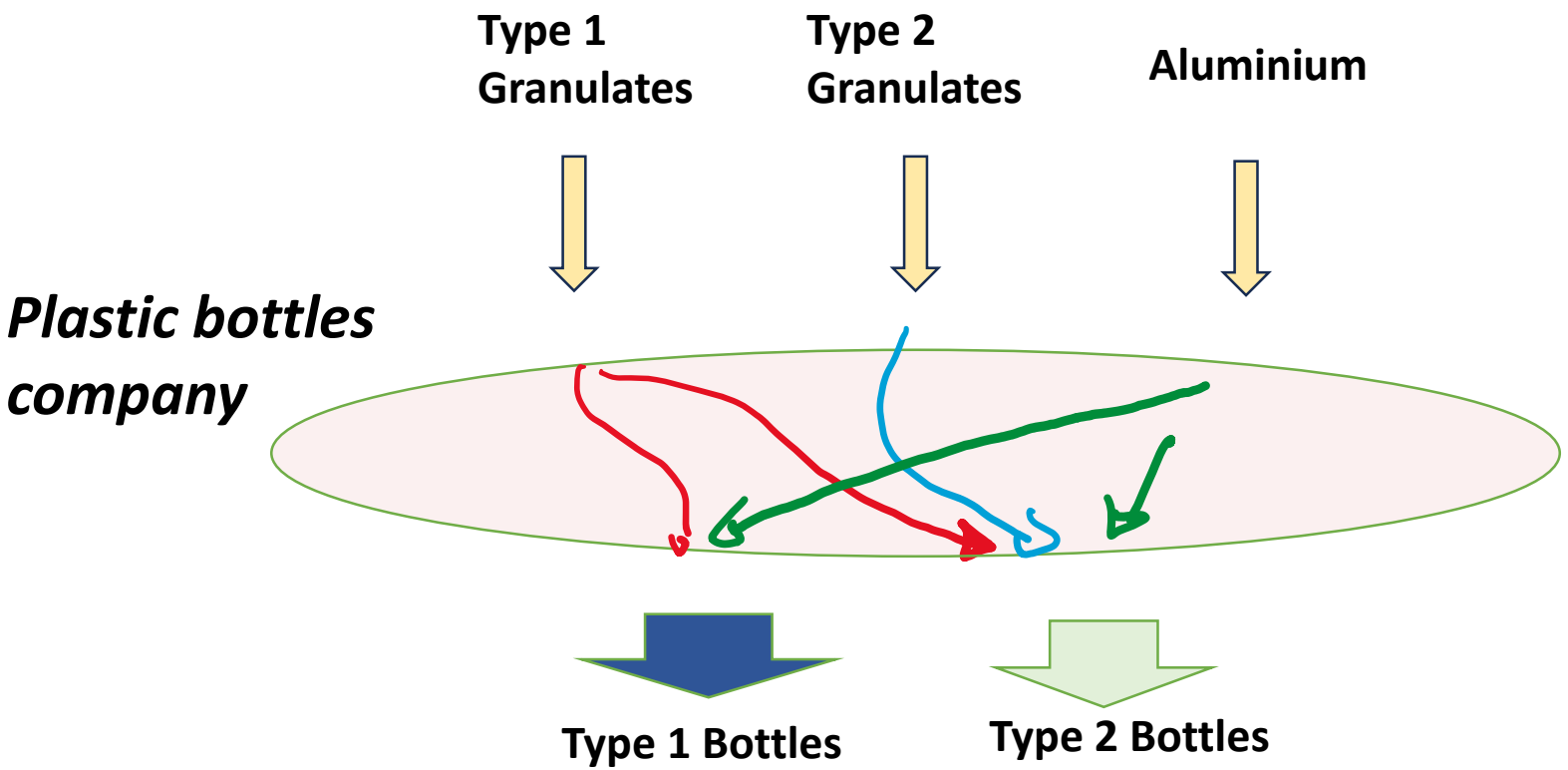
…as for standard financial accounting

Yet you still have the key accounting balance:

incoming carbons = 135 t.
=
outgoing carbons + inventory variation
= 132 t + 3 t.

How to allocate incoming carbons to outgoing products?

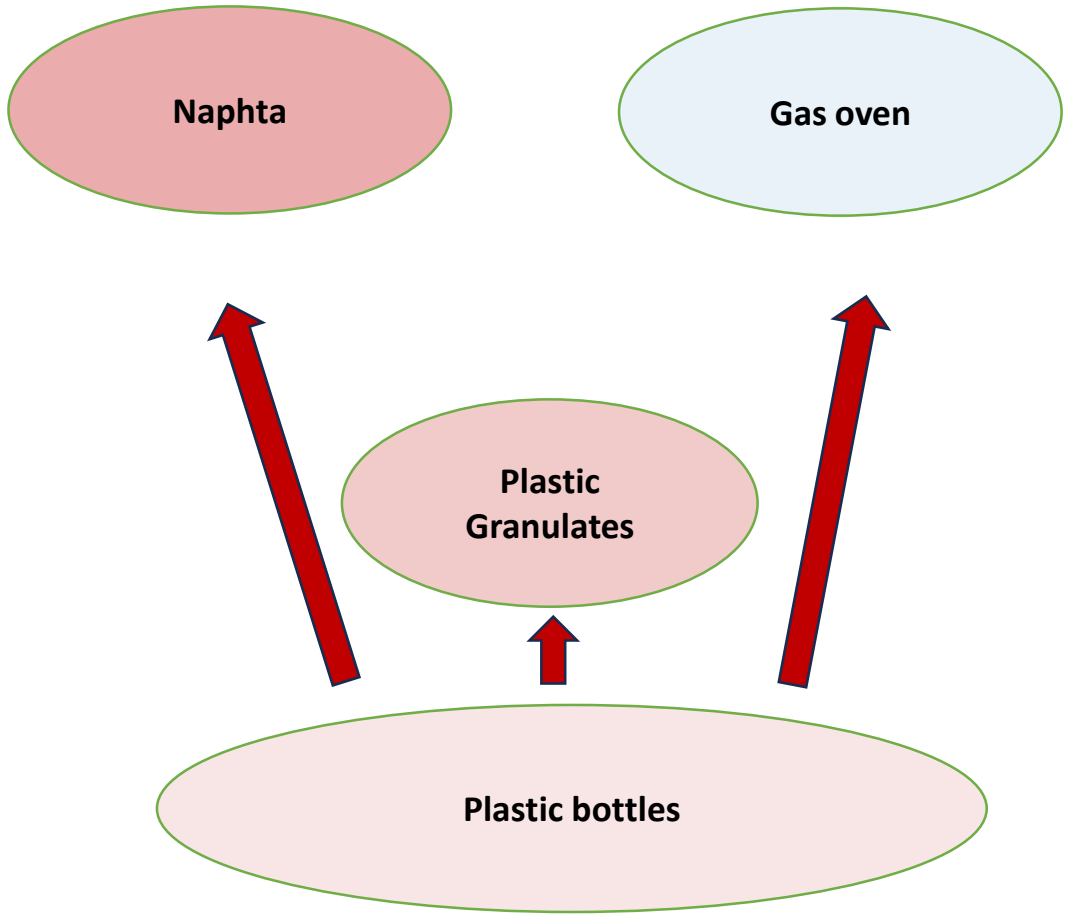
Well, as usual cost accounting.



Plastic processing Company	Type 1 Bottles	Type 2 Bottles
Type 1 Granulates	0,4	0, 23
Type 1 Granulates	0,1	-
Aluminium	0,6	0,45

You obtain a corporate *Supply and Use Table*, here as ratios of inputs on outputs, i.e. a corporate I/O table.

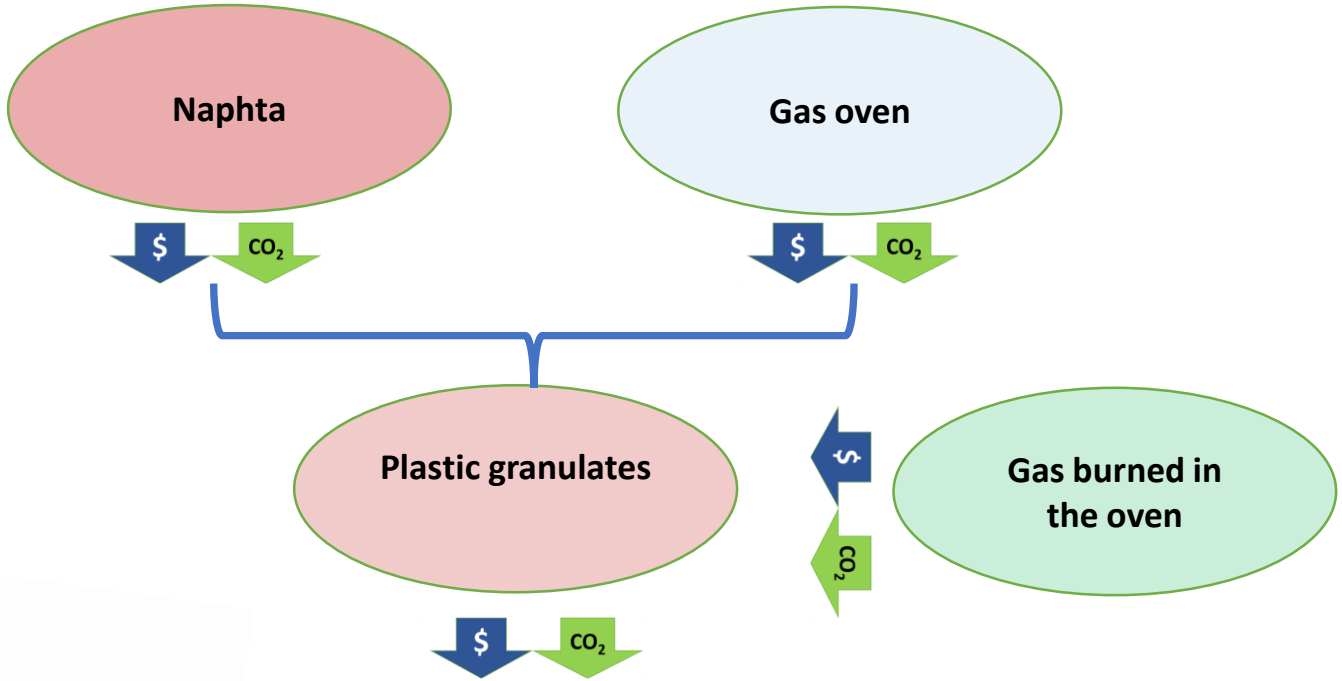
“CSRD” method (as of today): data are collected, looking upstream, by the customer/buyer (at destination)

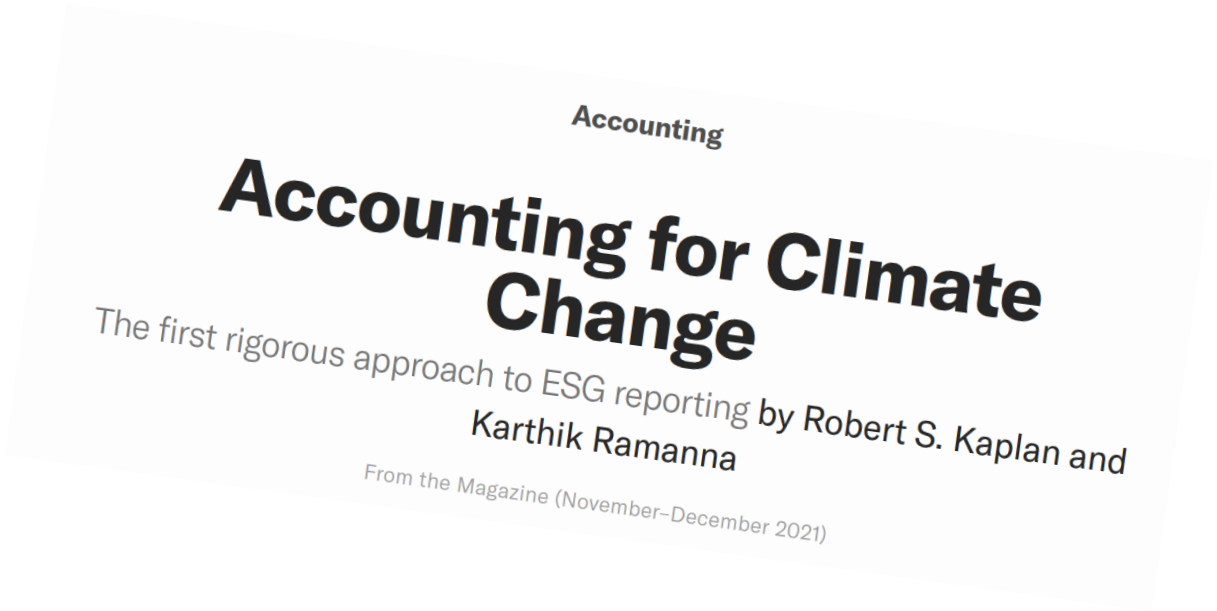


The bottle producer begs information from suppliers of rank 1, 2, 3...

It clumsy, costly, unreliable and open to manipulation

The “carbon accounting” method:
data are provided, downstream, by the seller
(at source)




Accounting

Accounting for Climate Change

The first rigorous approach to ESG reporting by Robert S. Kaplan and Karthik Ramanna

From the Magazine (November–December 2021)

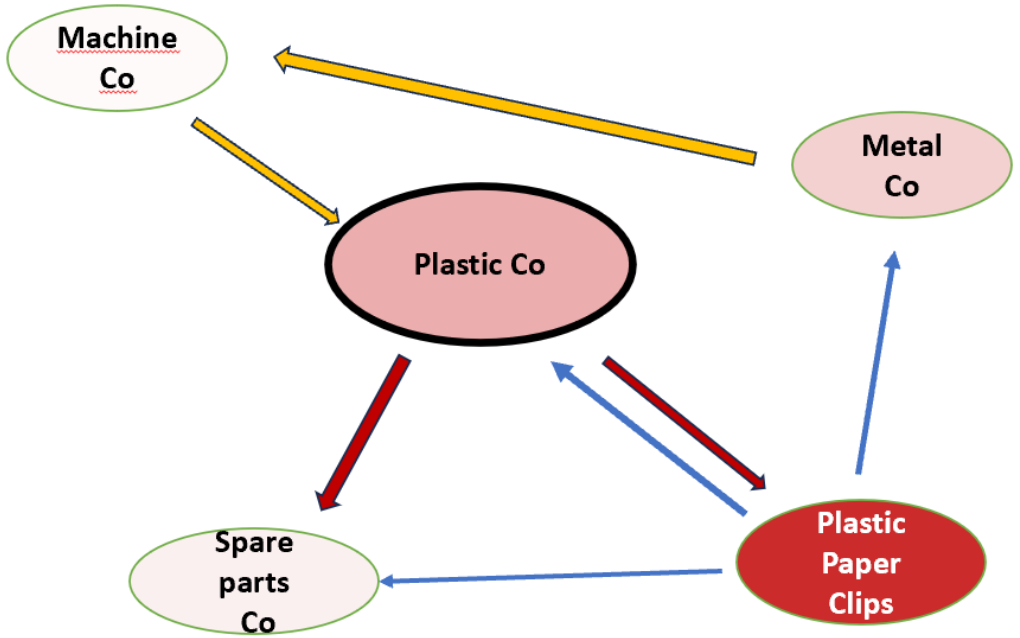
That’s now a common practise of some corporates

Tenet #2: Macro perspective

The systemic gain from pushing carbon data downstream

If everyone agrees to supplying carbon data downstream, then Plastic Co just gets readily its necessary data

At macro level, the economy is very circular.



Outputs

Inputs

	Plastic	Spare Parts	Metal	Machine	Paper Clips
Plastic					
Spare Parts					
Metal					
Machine					
Paper Clips					

I/O matrix at micro nomenclature level

Ulf von Kalckreuth, 2022, *Product level greenhouse gas contents – how to get there?*

Some reminders on I/O analysis: three key results

Let's call *A* the I/O matrix, assuming it is well-behaved, *à la* Leontief.

e **= vector of gross unit carbon footprints (in CO2e kg),**
q **= vector of gross production (in €m),**

d **= vector of direct unit emissions.**
f **= vector of final demand.**

We have the dual set of equations:

$$(1) \quad e' = e'A + d'$$

indirect direct

$$(2) \quad q = Aq + f$$

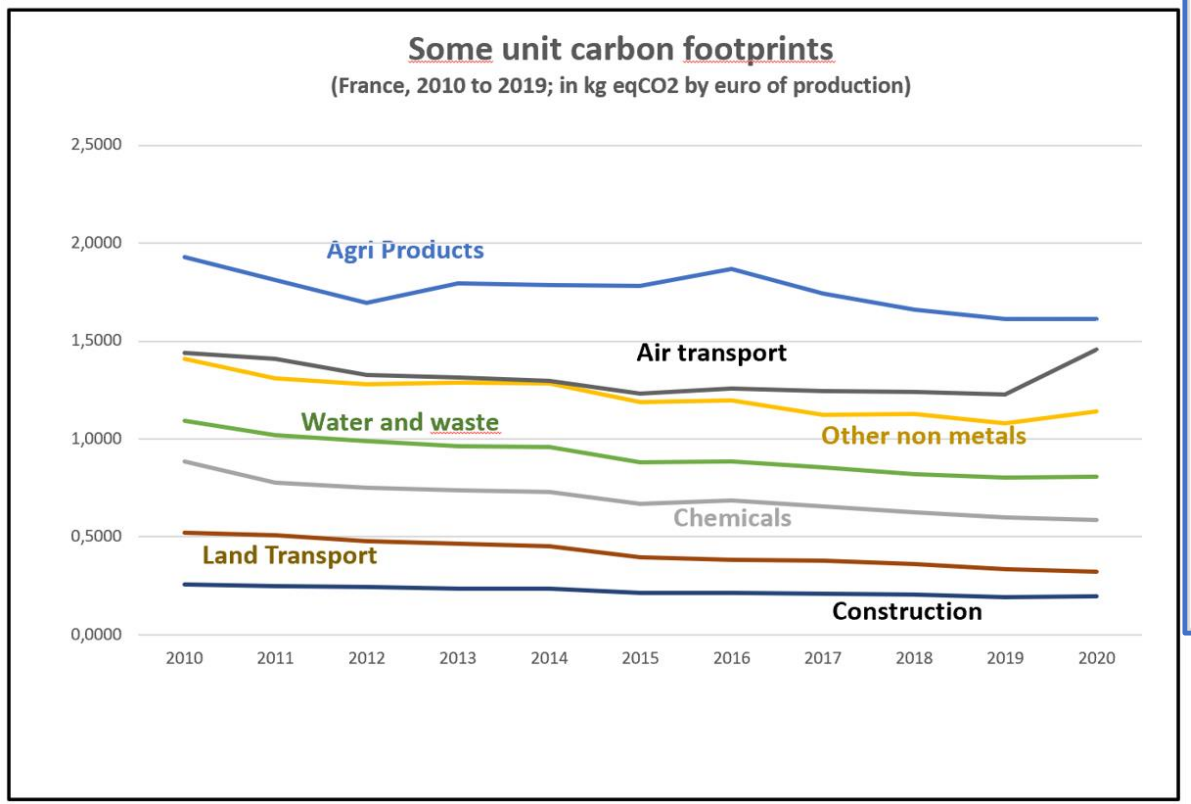
… out of which we obtain *e* and *q* as:

$$(1bis) \quad e' = d'(I - A)^{-1} = d'L$$

$$(2bis) \quad q = (I - A)^{-1}f = Lf$$

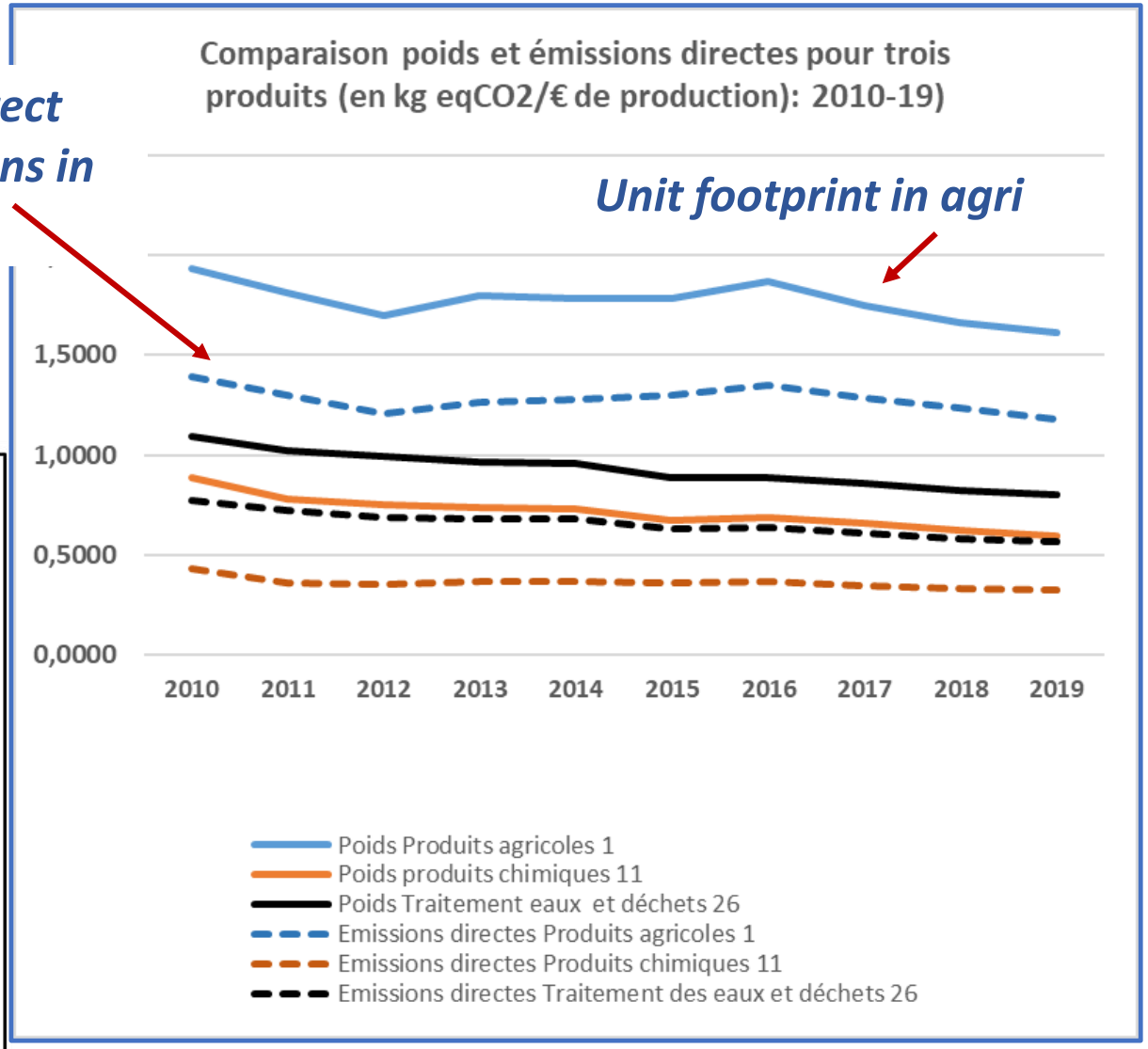
Result #1: Once you know direct emissions *d*, you get carbon footprints for the production sector. Same for quantities.

Simulation on French data



Unit direct emissions in agri

Unit footprint in agri



Source: MTE, INSEE, authors; #64 nomenclature, France

Result #2: Carbon footprints can be obtained recursively:

$$\boldsymbol{e' = d'(I - A)^{-1} = d'(I + A + A^2 + \cdots + A^n + \cdots)},$$

The dominant eigenvalue (<1) conveys the dynamics of the convergence.

Result #3: The key Emission Conservation Equation:

$$(3) \quad \boldsymbol{e'f = d'(I - A)^{-1}f = d'q}$$

Gross emissions of final demand

Direct emissions of gross production

… which allows another definition of the **product footprint**:

= the amount of <u>direct</u> emissions necessary to produce one unit of it, directly and indirectly.

paper clip

Example:

$f^{\text{paper clip}} = (0, 0, .., 1, 0, .., 0)$

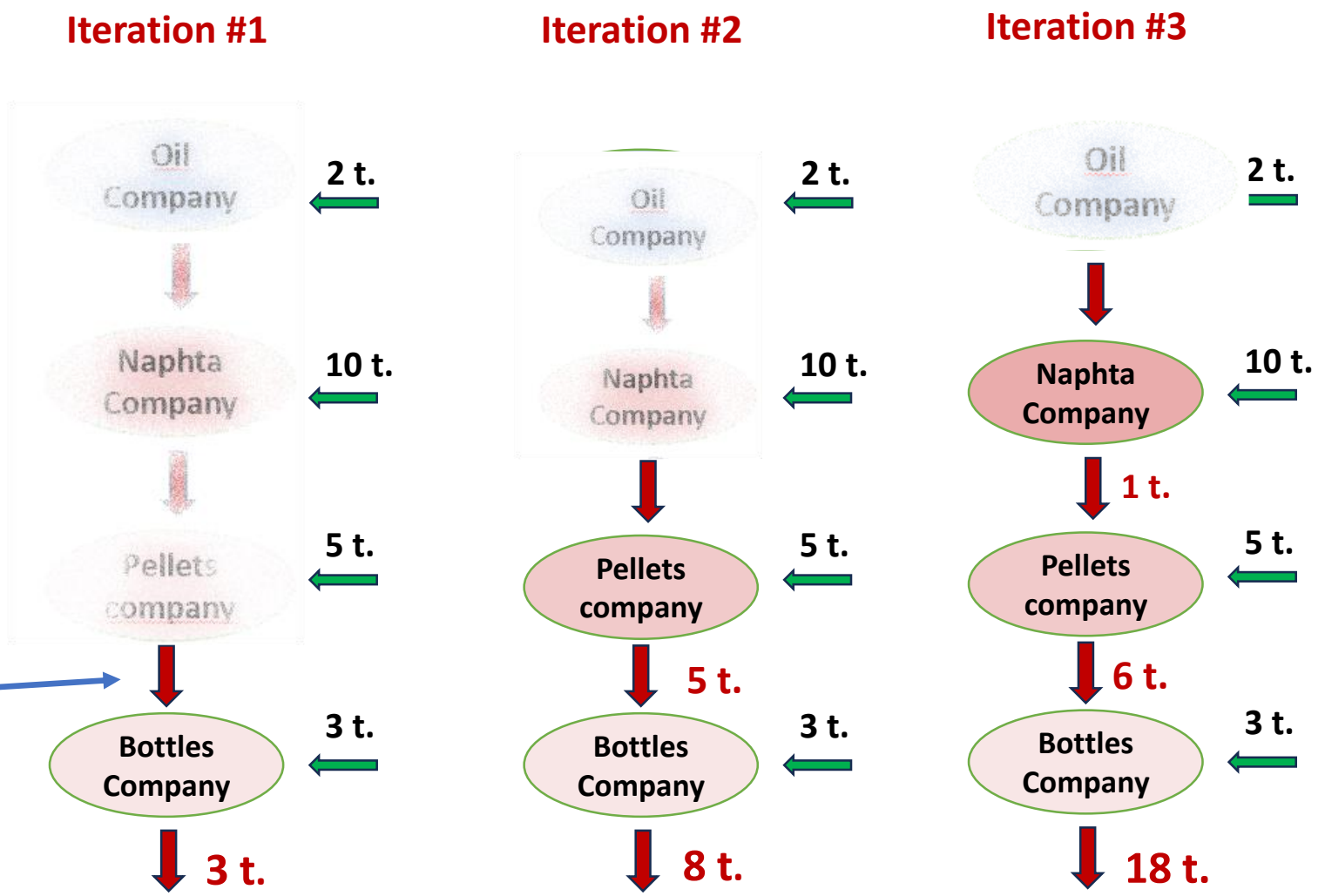
Inserting into eq. (3):

$$\boldsymbol{e^{\text{paper clip}} = e' f^{\text{paper clip}}}$$

$$\boldsymbol{= d' q^{\text{paper clip}}}$$

From result #2: the ramping up of the system, or the leapfrog game

Suppose firms only disclose the direct emissions they incur.



As if indirect emissions of the bottling company were zero…

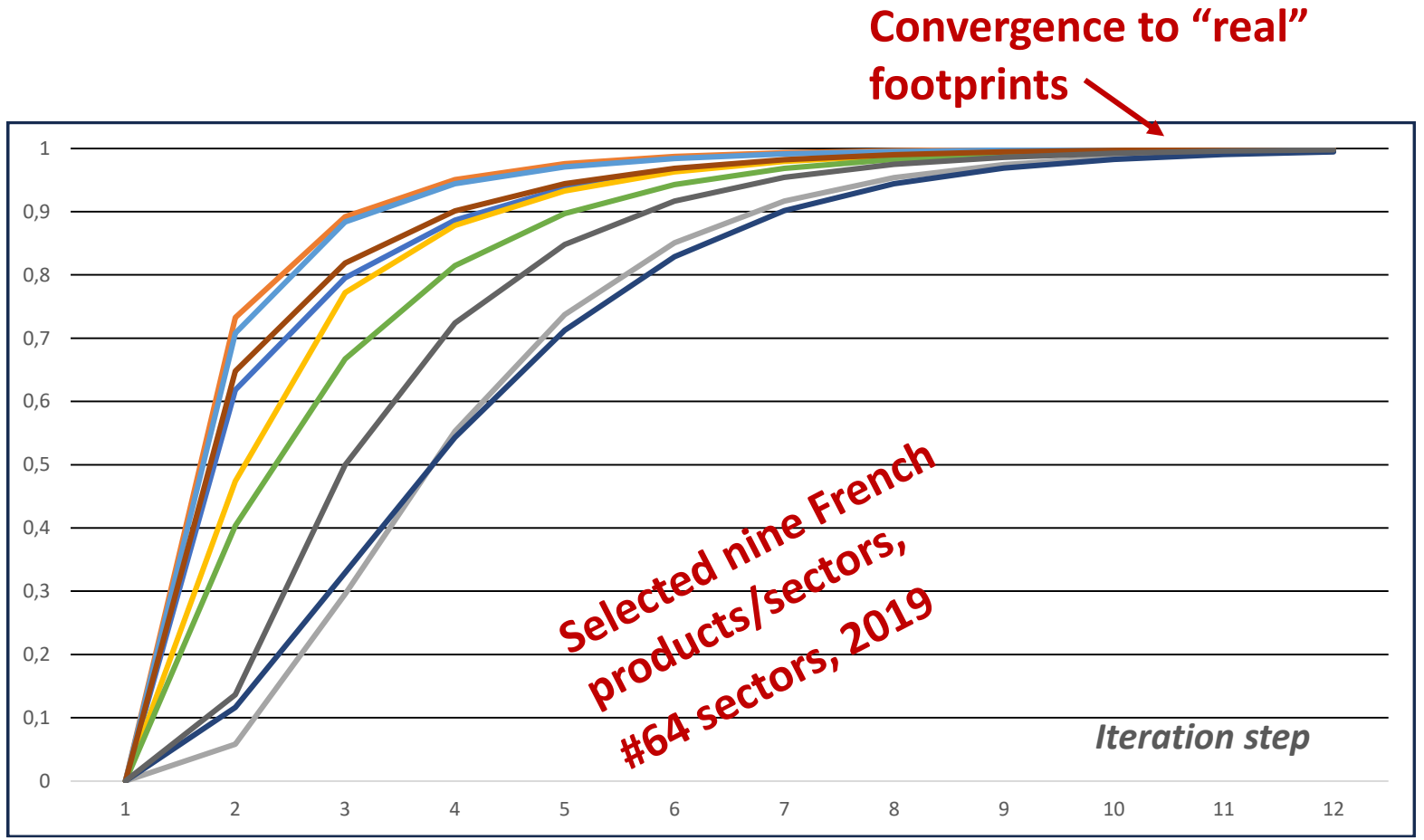
etc., up to the total of 20 tons…

… in 4 rounds of trade

The footprint vector *e* is also an accumulation of direct emissions:

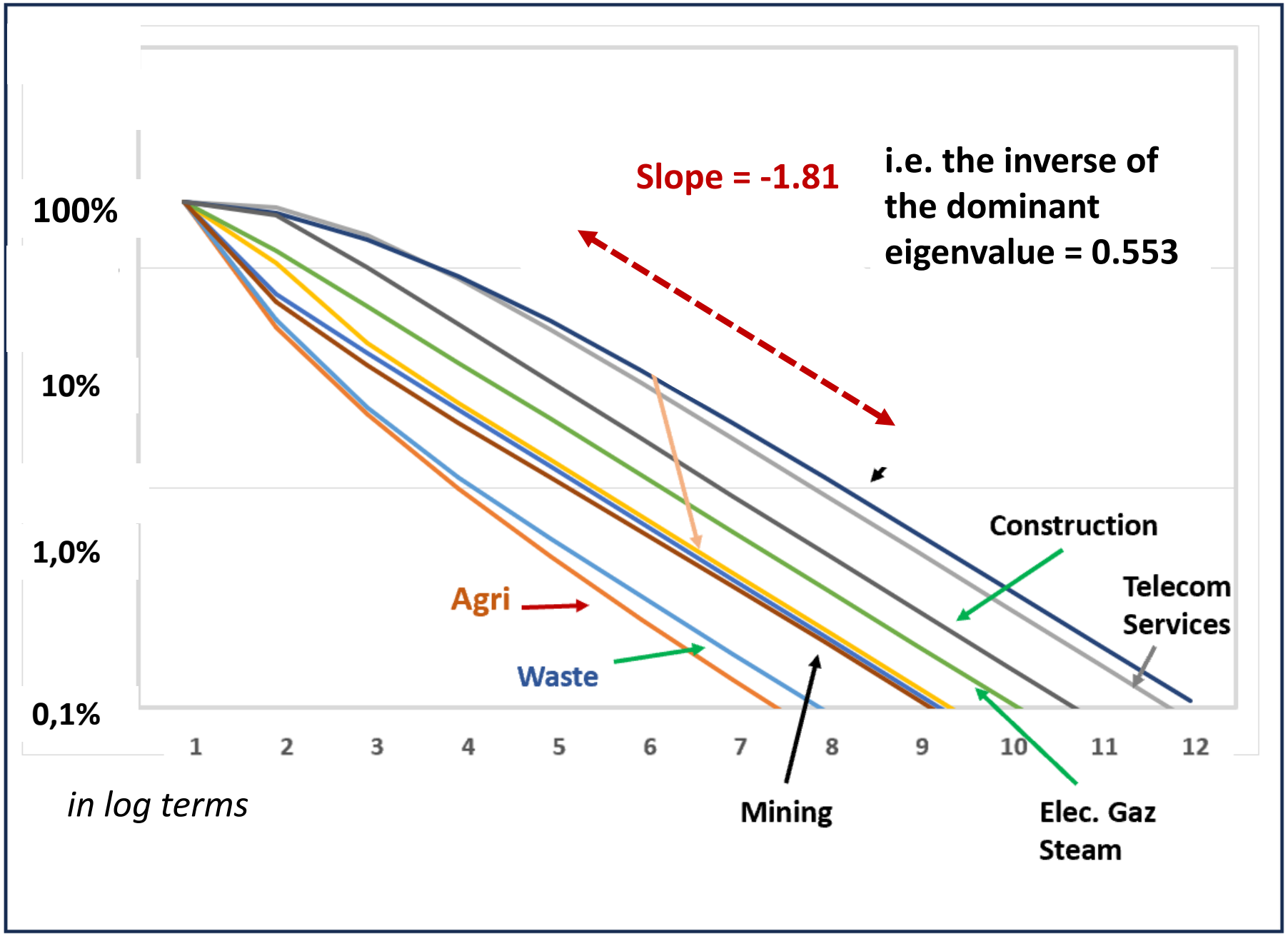
$$
\begin{aligned}
e' = \quad & d' && \text{direct emissions of the company} \\
& + d'A && \text{direct emissions of tier 1 suppliers} \\
& + d'A^2 && \text{of tier 2 suppliers} \\
& + \ldots && \ldots \\
& + d'A^n && \text{of tier } n \text{ suppliers} \\
& \ldots && + \\
& = d'(I - A)^{-1}.
\end{aligned}
$$

Therefore, any reporting error on indirect emissions vanishes out progressively



Here, we assume that the error/ absence is set at 100%...

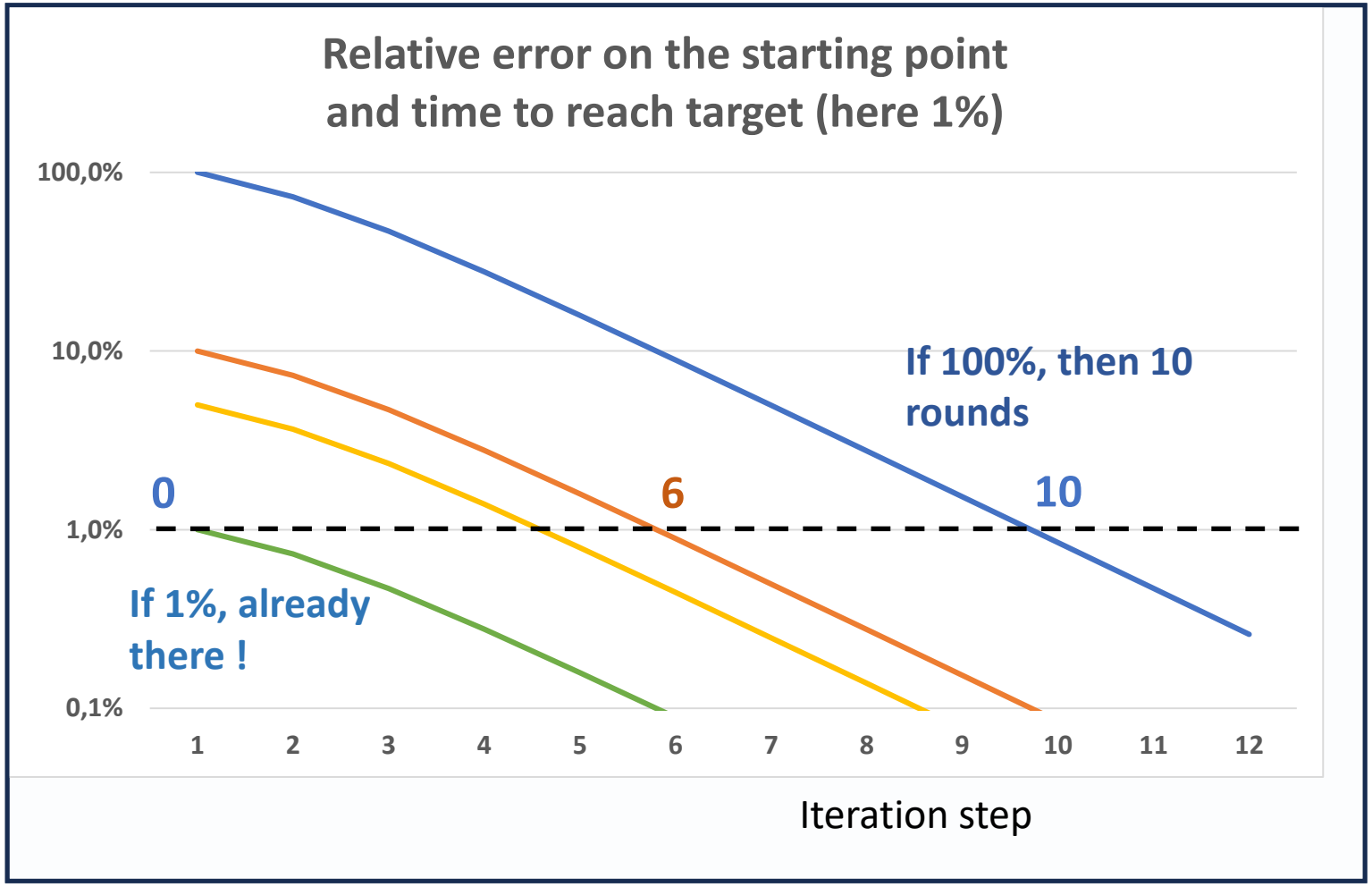
…or, only cumulated direct emissions are reported.



… and the rate of accretion is rapidly the same

(French data, 2019, #64)

Better having good initial estimates than bad ones

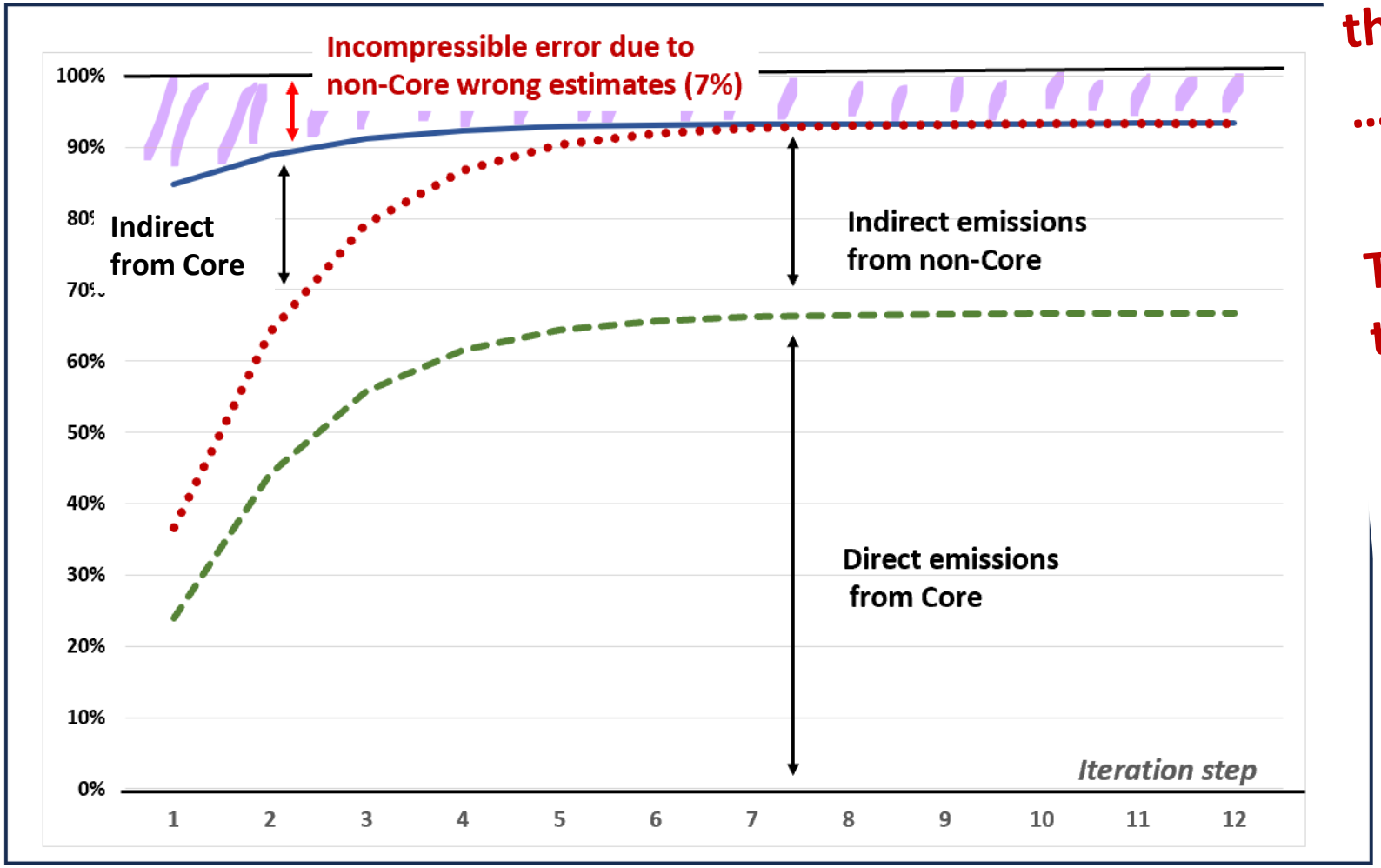


Average error across all sectors; France, 2019, #64.

The speed of propagation of an error (or a shock) is always the same.

But you need less time to reach, say, the 1% threshold by starting closer.

The case when there is some misreporting
(starting from 80% of « real » footprint values across the board(*))



(*) simulation by the authors on World data by Figaro, 2019

Conclusion: biases vanish automatically if endogenous in the iterative process…

… and remains if not.

There is a rationale for correcting this (generally) negative bias.

In any case, there are always new products, new companies… 'Real' footprints are a moving target.

Carbon accounting is all about incentives

- Carbon pricing, subsidies to green tech and green regulation are three policy instruments *en route* to net-zero.
- The fourth instrument is carbon accounting, because of its specific role on motivations.
- When put in place, it pervades the whole corporate organization: sales, purchasing, production and finance departments.
- Here, the pressure to do the right thing comes from market discipline, marketing advantages or, casually, ethical considerations.

Carbon accounting is a process of *generative distributed intelligence*, *gen-DI*, that can be applied for any “scarce” input: plastics, water, labor…

Practical summary of the process

1- The company records all its **direct emissions** on its books (tenet #1)

2- It records also the emissions embedded in all acquired units of goods and services as reported by its suppliers (**indirect emissions**) (tenet #1)

3- Absent this information, the company makes its **best estimate** of emissions embedded in such purchased products, from available and reliable sources. The process is duly audited.

That's exactly what CSRD requires (or "bilan carbone"/ BEGES in France)

4- The total emission is allocated to its sales, product-wise, and reported to its clients. (tenet #2)

Tentative foray. More on the dynamics of the economy:

Three metrics, pertaining only on the industrial structure (and not on the amount of emissions) command the dynamics of the economy.

- The dominant eigen value λ reflects both the speed of convergence and the "productivity" of the economy (1 – λ). *You harvest at least 100 tons of wheat out of 60 of seeds* ➔ *eigenvalue = 0.6.*

- The two dominant eigen vectors, which concentrate the largest slice of the information
  - ✓ On the right-hand side: the dynamics of quantities: which sector/product has the most importance in the flows of quantities?
  - ✓ On the left-hand side: the dynamics and propagation of values/emissions?

	Year 2010	
	Left handside eigen vector #1	
	Eigen value	0,565228
24	Électricité, gaz, vapeur et air conditionné	3,9%
15	Produits métallurgiques	3,3%
20	Véhicules automobiles, remorques et semi-remo	3,3%
10	Produits de la cokéfaction et du raffinage	3,1%
11	Produits chimiques	3,1%
21	Autres matériels de transport	3,0%
8	Papier et carton	3,0%
13	Produits en caoutchouc et en plastique	2,7%

Based only on the industrial structure of the economy, these are the most relevant sectors/products for smoothing the transfer of emissions through the economy.

Important to focus policy intervention.

	Year 2019, France	
	Left handside eigen vector #1	
	Eigen value	0,553087
	Eigen Vector #1	
21	Autres matériels de transport	3,9%
15	Produits métallurgiques	3,3%
24	Électricité, gaz, vapeur et air conditionné	3,3%
10	Produits de la cokéfaction et du raffinage	3,1%
20	Véhicules automobiles, remorques et semi-remorques	3,1%
8	Papier et carton	3,0%
19	Machines et équipements n.c.a.	3,0%
5	Produits des industries alimentaires, boissons et produits à b	2,7%

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