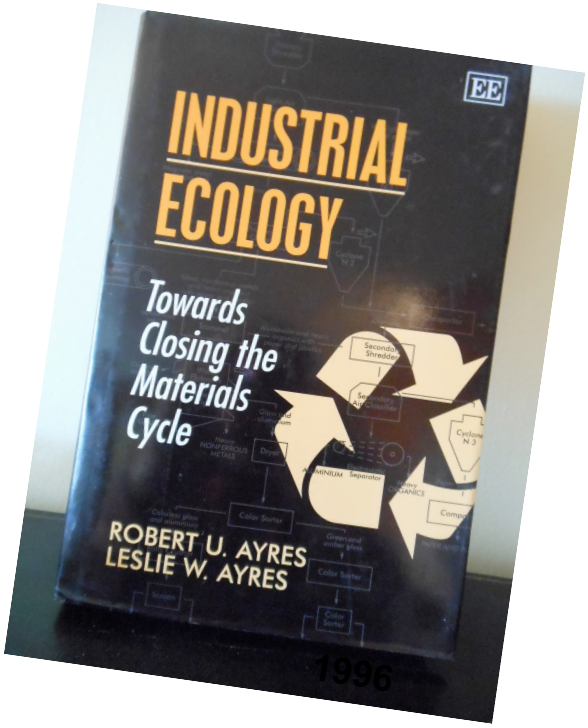
Material Flow Accounting and Analysis



1969

idea of material accounting

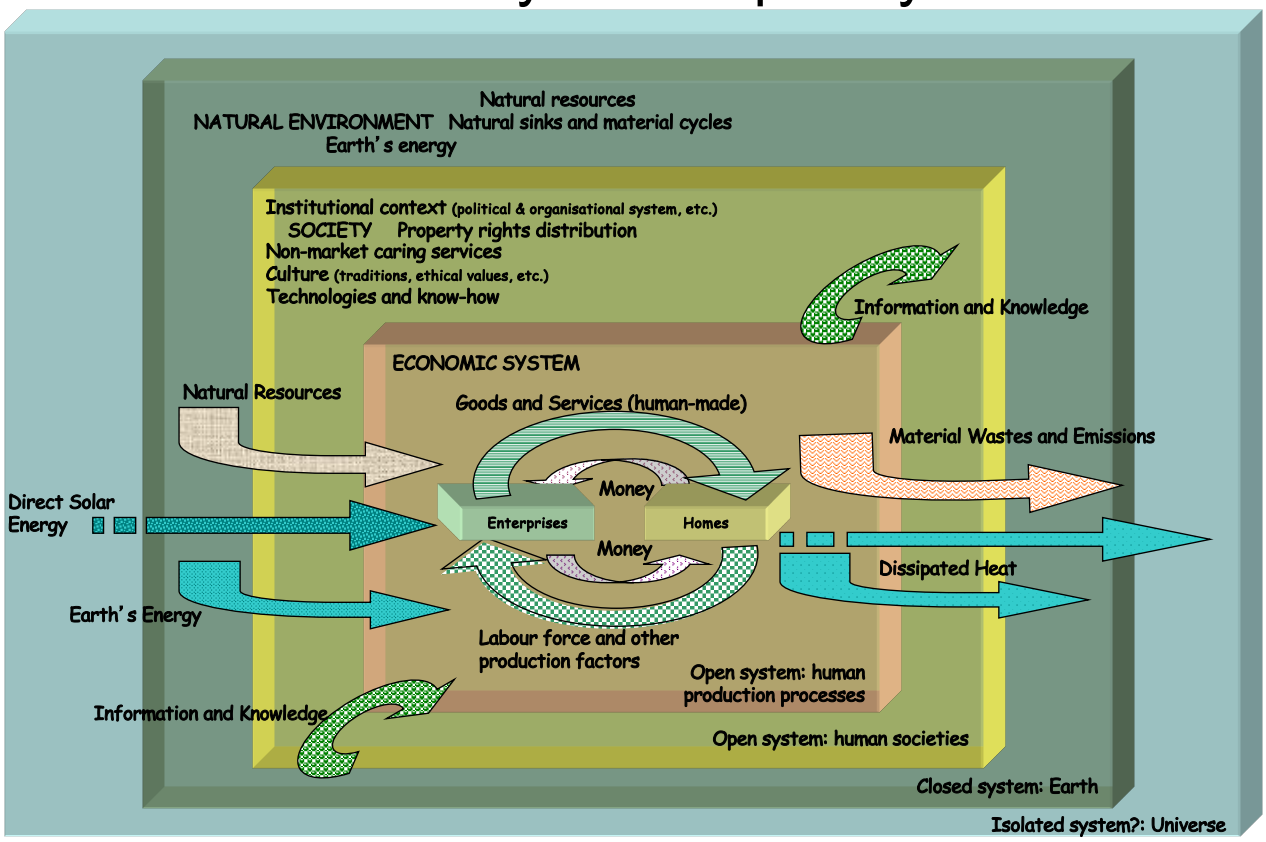
AYRES, Robert U.

KNEESE, Allen V.

Production, consumption, and externalities. *The American Economic Review*, 1969, 59.3: 282-297.

In the emerging discipline of industrial ecology,
researchers view modern
economies, metaphorically, as living organisms.
Industrial economies "ingest"
raw materials, which are "metabolized" to produce goods and services, and they "excrete" wastes in the form of discarded materials and pollution.
WRI 2000, p 1

The economy as an open system



JMAlier: The environmentalism of the poor

RESOURCE FLOWS:

THE MATERIAL BASIS OF INDUSTRIAL ECONOMIES

ADRIANSEE et AL.

1997 World Resource Institute

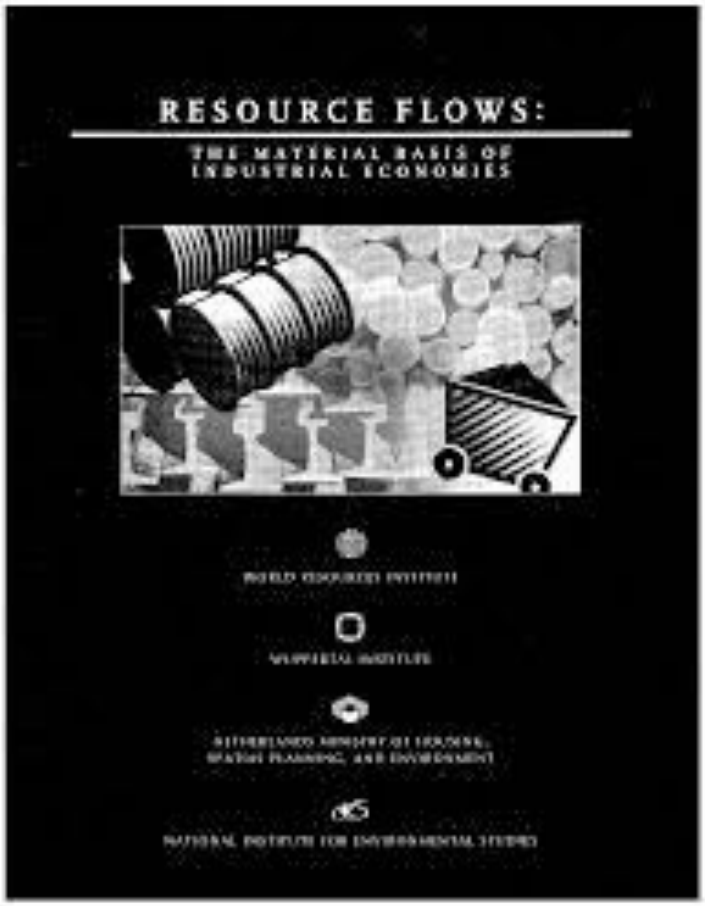
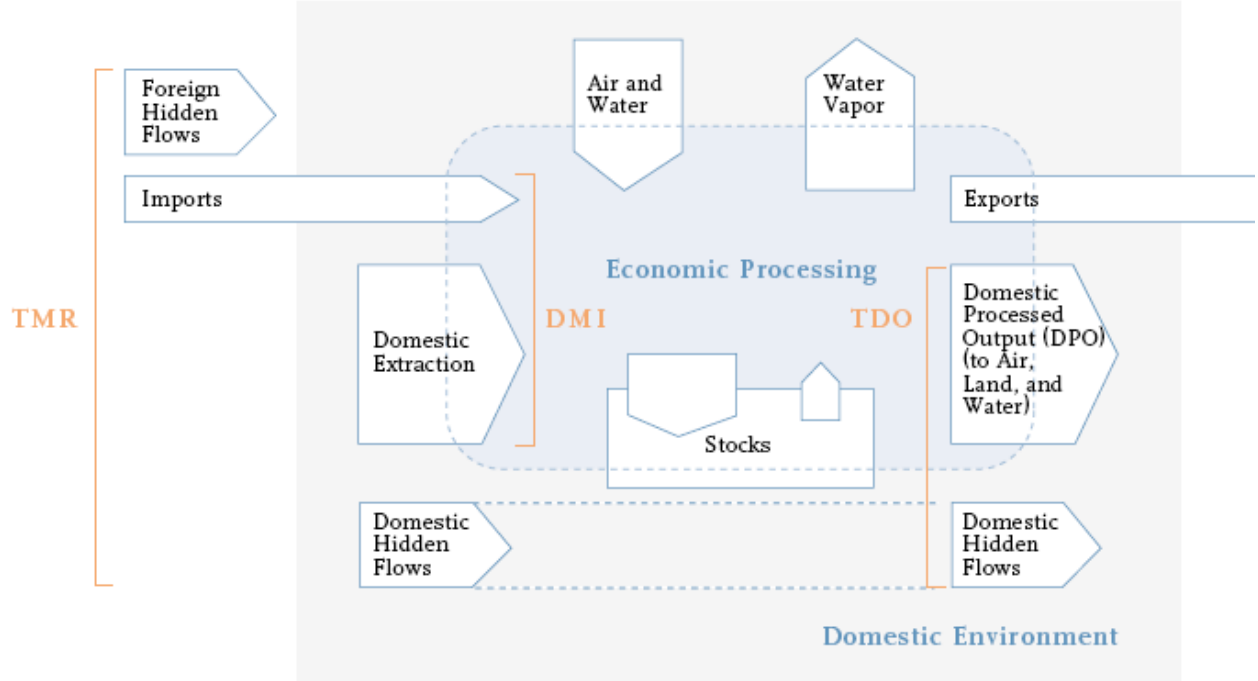


FIGURE 1 | THE MATERIAL CYCLE



TMR (Total Material Requirement)=DMI+Domestic Hidden Flows+Foreign Hidden Flows

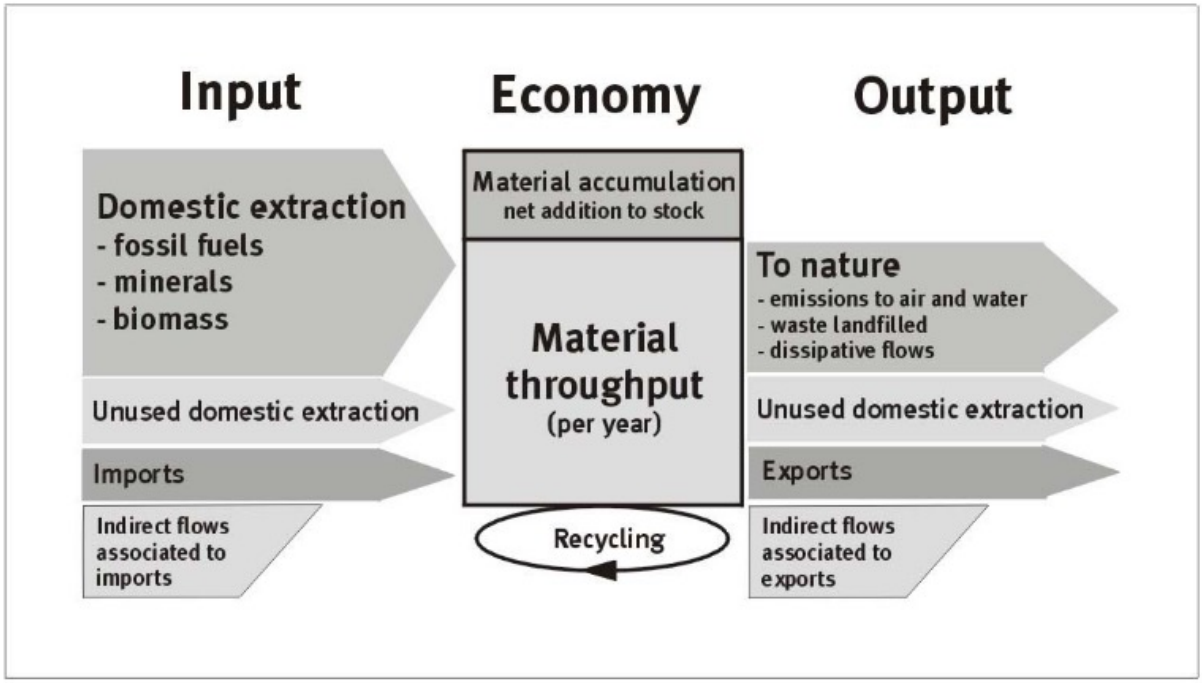
DMI (Direct Material Input)=Domestic Extraction+Imports

TDO (Total Domestic Output)=DPO+Domestic Hidden Flows

NAS (Net Additions to Stock)=DMI–DPO–Exports

DPO (Domestic Processed Output)=DMI–Net Additions to Sto

Figure 2: General scheme for economy-wide MFA, excluding water and air flows



Source: EUROSTAT (2001)

Material balance for Italy (1997)

Importazioni	289	Esportazioni	111
di cui:			
Materie prime e semilav.	*276*	Accumulo di stock	467
Prodotti finiti	*13*	*di cui:*	
		Infrastrutture di trasporto ed edifici	*290*
Estrazione interna		*Macchinari*	*13*
di materiali utilizzati	616	*Altri beni durevoli*	*8*
		Variazione delle scorte	*157*
di cui:		*Animali vivi*	*-1*
Combustibili fossili	*20*		
Minerali	*409*	Emissioni	480
Biomasse	*187*	*di cui:*	
		Anidride carbonica	*457*
Input ausiliari	677	*Altre emissioni atmosferiche*	*12*
di cui:		*Emissioni in acqua*	*11*
Aria per combustione, respirazione, decomposizione	*574*	Rifiuti deposti in discarica	56
Acqua per abbeveramento	*103*	Utilizzi dissipativi di prodotti e perdite dissipative	144
		Altri output gassosi	331
		di cui:	
		Vapore acqueo da combustione	*250*
		Anidride carbonica e vapore acqueo da respirazione	*81*
Discrepanza statistica	7		

Aldo Femia *Istat, Direzione Centrale della Contabilità Nazionale*

SOME USEFUL DEFINITIONS

Direct Material Input (DMI) :
Flow of natural resource commodities that enter the industrial economy for further processing.
Included in this category are
grains used by a food processor, petroleum sent to a refinery, metals used by a manufacturer, and logs taken to a mill

Total Material Requirement (TMR):
This is the sum of the total material input and the **hidden or indirect material flows**, including deliberate landscape alterations.
It is the total material requirement for a national economy,
including all, domestic and imported natural resources.

The TMR gives the best overall estimate for the potential environmental impact associated with natural resource extraction and use.

RESOURCE FLOWS: THE MATERIAL BASIS OF INDUSTRIAL ECONOMIES p.8
ADRIANSEE et AL. **1997** World Resource Institute

SOME USEFUL DEFINITIONS

Hidden material flow: This is the portion of the total material requirement that never enters the economy.
It is the natural resource use that occurs when providing those commodities that do enter the economy.

The hidden material flow comprises two components, **ancillary flows** and **excavated or disturbed** flows.

1. Ancillary material flow (auxiliary)
This is the material that must be removed from the natural environment, along with the desired material to obtain the desired material.
Some examples are the **portion of an ore**
that is processed and discarded to concentrate the ore and
the plant and forest biomass that is removed from the land
along with the logs and grain,

SOME USEFUL DEFINITIONS

2. Excavated and/or disturbed material flow.

This is material moved or disturbed to obtain a natural resource, or to create and maintain infrastructure.

Included in this category is the overburden
that must be removed to permit access to an ore body,
the soil erosion from agriculture,
and the material moved in the construction of infrastructure
(e.g. highway or a building,)
or in the dredging of harbors and canals

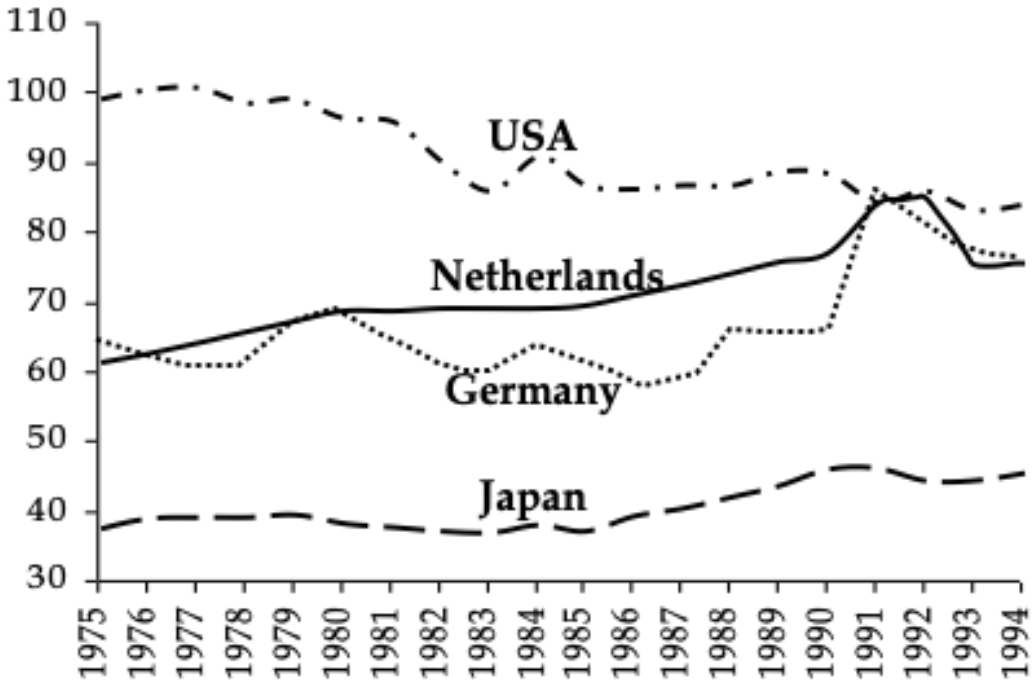
For simplicity, both ancillary and excavated or disturbed material have been combined into the single category of hidden material, even though they can have markedly different environmental impacts.

SOME USEFUL DEFINITIONS

Hidden flows have been calculated
for six categories of material flows:

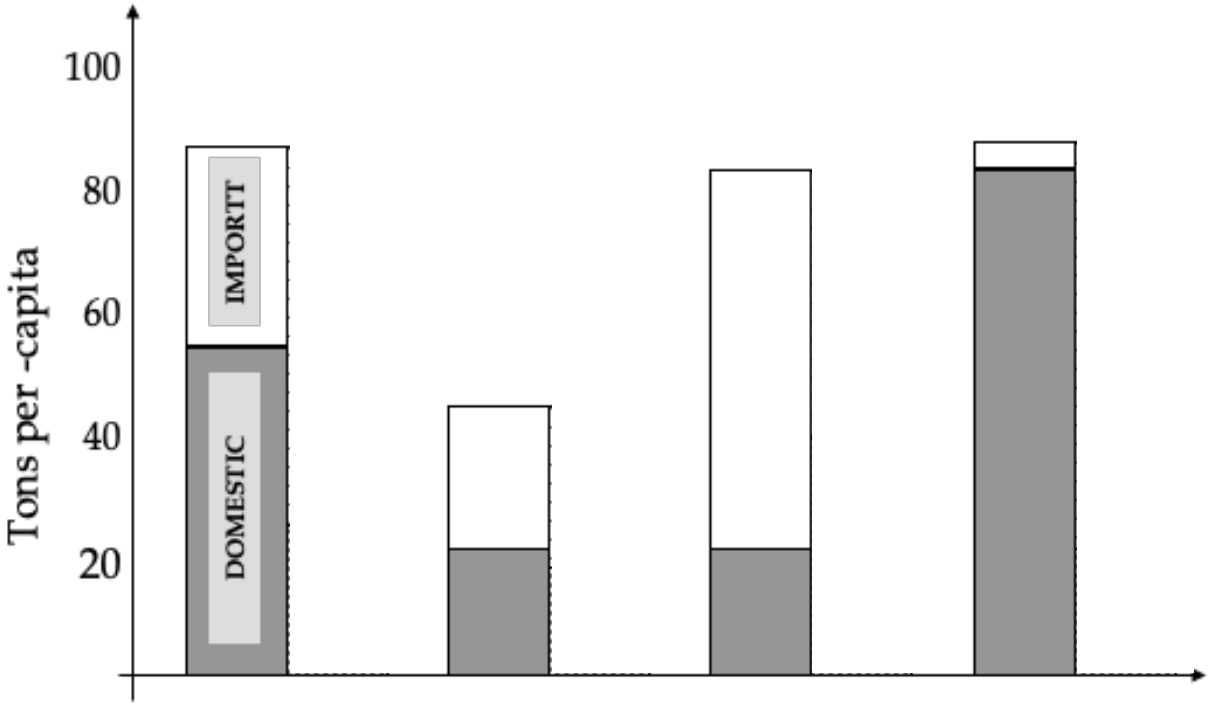
- fossil fuels,
- metals and industrial minerals,
- construction materials,
- renewable natural resources,
- infrastructure creation and maintenance, and
- soil erosion.

TMR per capita



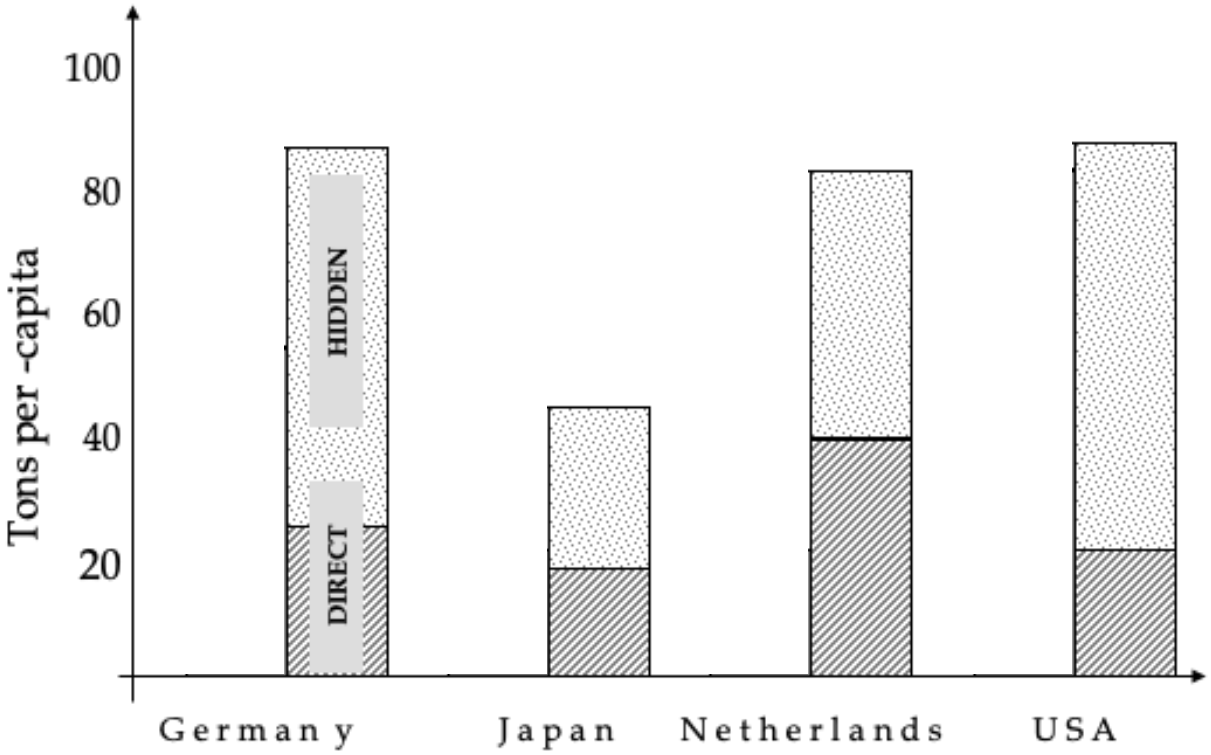
Adriansee et. al 1997

TMR COMPOSITION in 1991

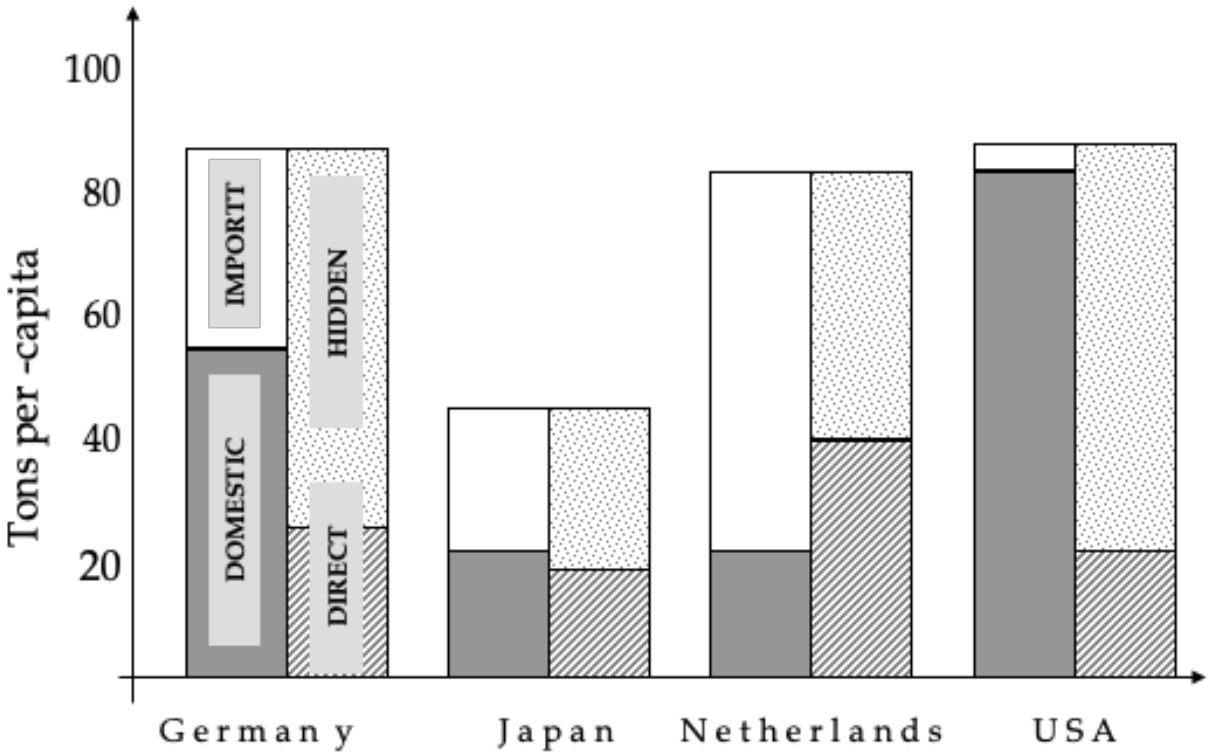


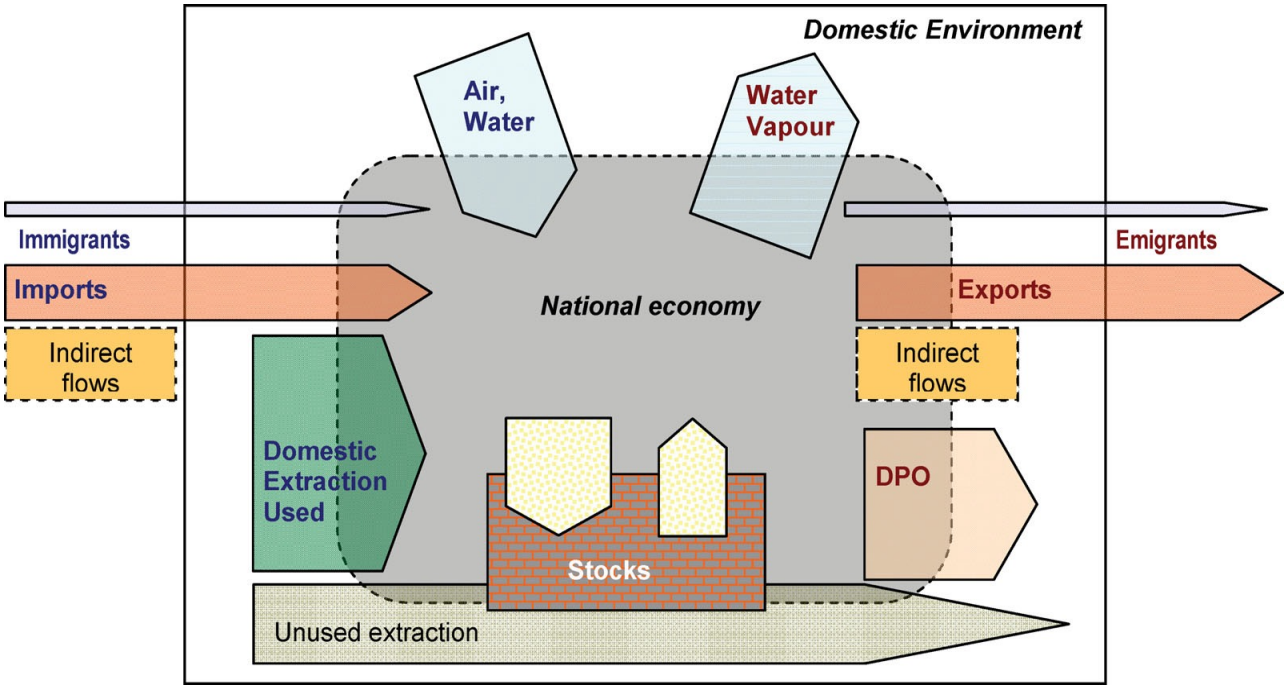
Adriansee et. al 1997

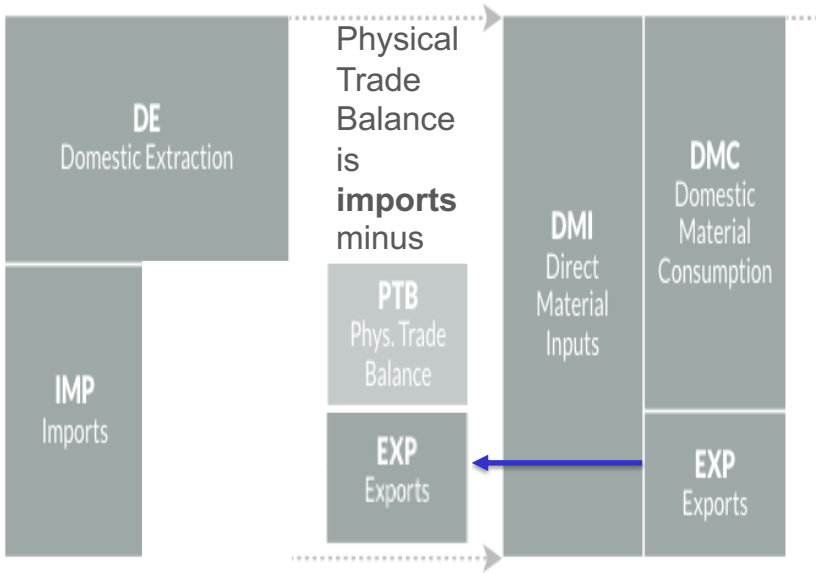
TMR COMPOSITION in 1991



Adriansee et. al 1997



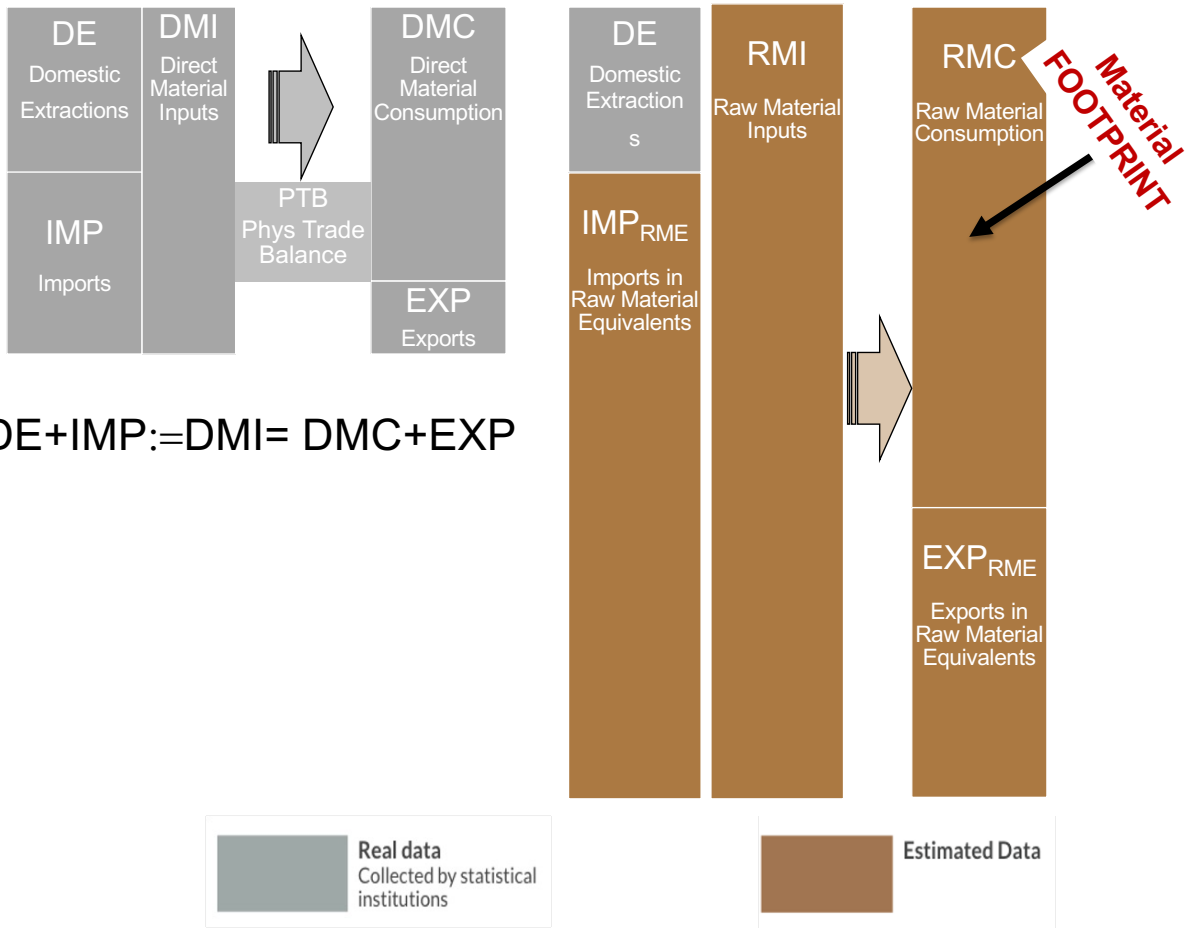




Domestic extraction (DE) comprises all biotic and abiotic raw materials that are extracted from the domestic environment and further used in production processes.

Direct imports (IMP) cover all imported commodities in tonnes. Traded commodities comprise goods at all stages of processing from raw materials to highly processed products.

Domestic Material Consumption (DMC) measures the total quantity of materials directly used within an economic system. DMC equals the sum of domestic extraction and imports minus exports.



The Raw Material Input (RMI) equals the sum of Domestic Extraction (DE) plus Imports in Raw Material Equivalents (IMP-RME).
RMI represents total final use of products in a country expressed in Raw Material Equivalents. It illustrates the amount of materials required along all supply chains as input to the production system in order to meet a country's consumption, investment, and export demand, both **from domestic and foreign origins**.

Raw Material Consumption (RMC) illustrates the domestic final use of products in terms of Raw Material Equivalents. RMC thus captures the amount of domestic and foreign extraction of materials needed along all supply chains to produce the final products **consumed in a country**.
RMC equals the sum of Domestic Extraction (DE) plus Imports in Raw Material Equivalents (IMP-RME) minus exports in Raw Material Equivalents (EXP-RME), i.e. trade balance in RME.

Physical Trade Balances:
imports minus **exports**

The Physical Trade Balance (PTB) measures the physical trade surplus or physical trade deficit of a country.

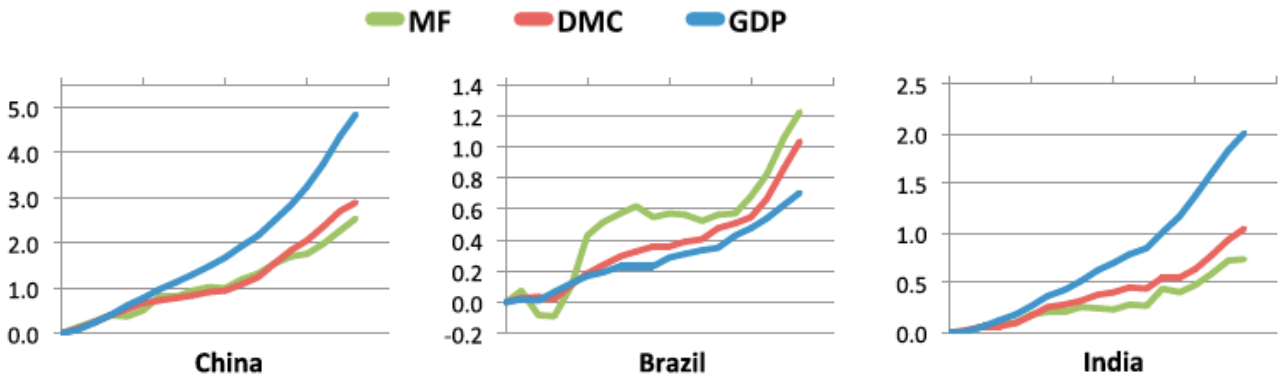
PTB= IMP-EXP

The Raw Material Trade Balance (RTB) measures the physical trade surplus or physical trade deficit of a country, including domestic and foreign extraction of materials needed along all supply chains to produce the imports and exports.

RTB = IMP$_{RME}$ -EXP$_{RME}$

Wiedmann, T. O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., & Kanemoto, K. (2015). The material footprint of nations. *Proceedings of the national academy of sciences*, *112*(20), 6271-6276.

Fig. 3. Relative changes in total resource use (MF and DMC) and GDP-PPP-2005 between 1990 and 2008
[values are plotted as ΔX/X = (Xt2 − Xt1)/Xt1; t1 = 1990].



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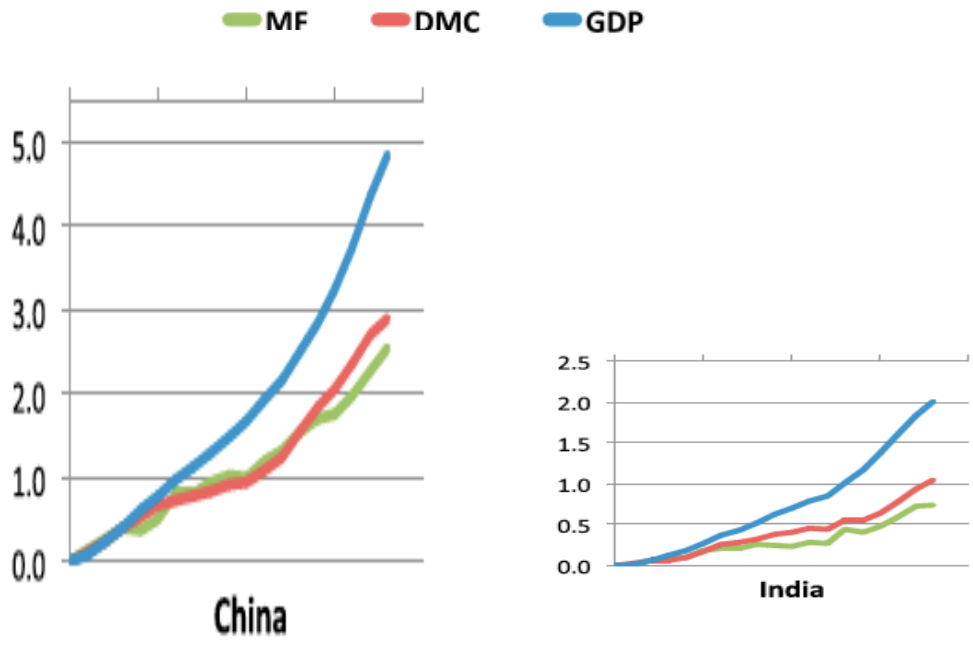

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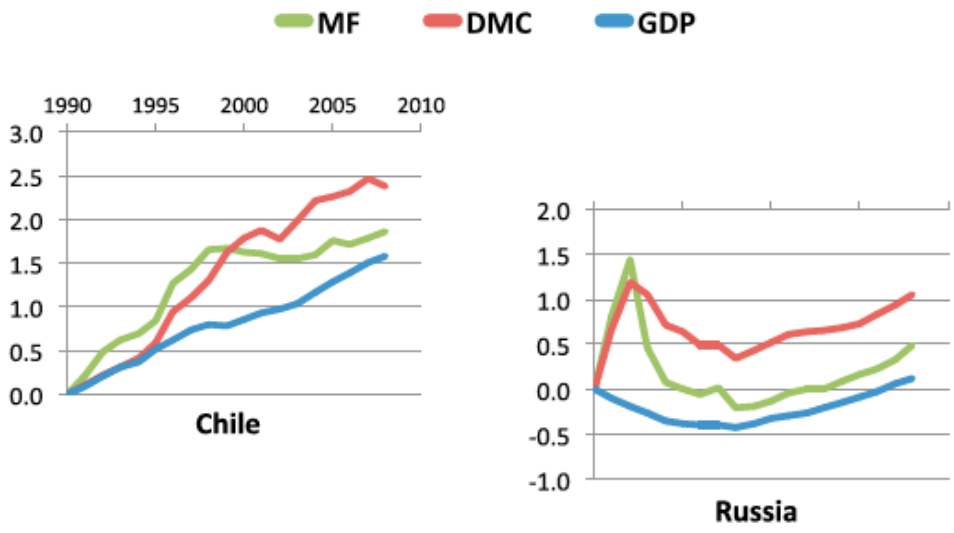

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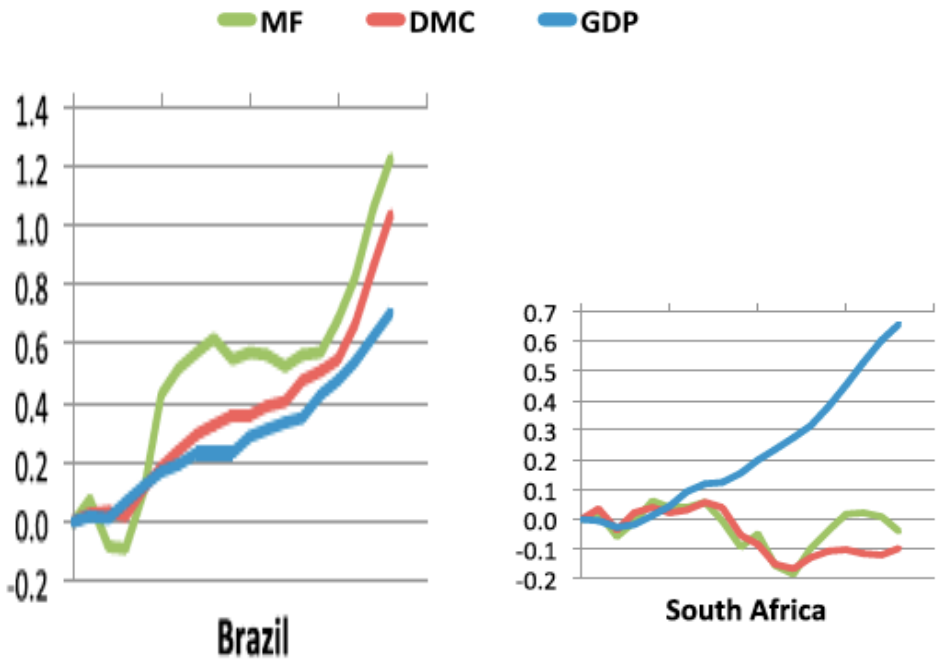

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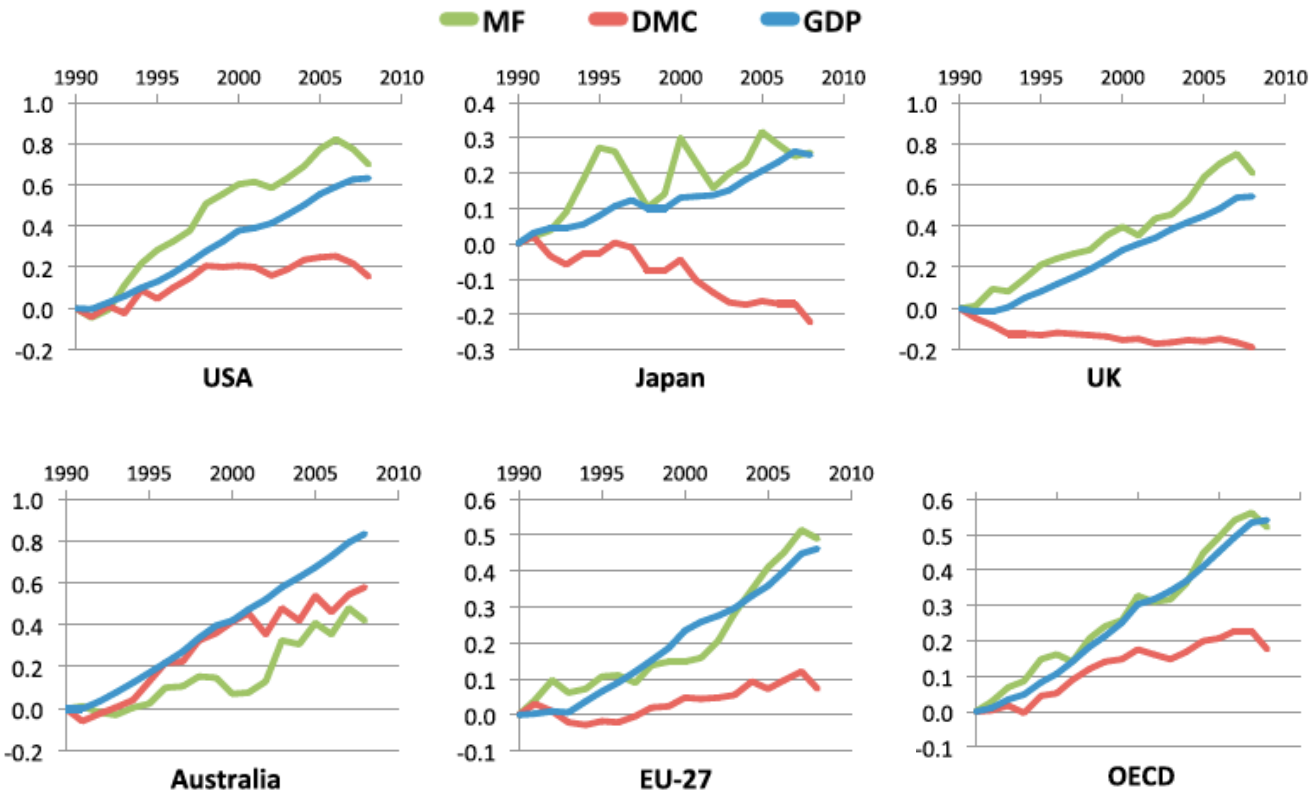
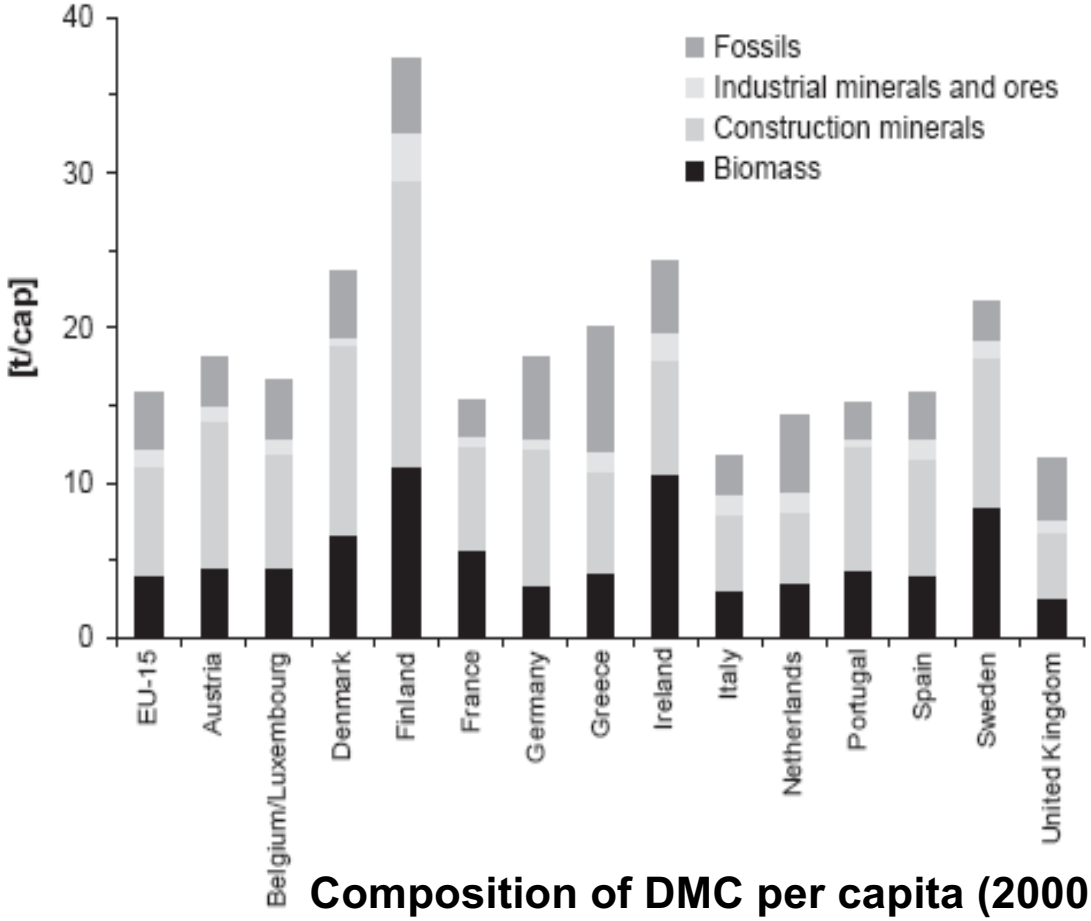
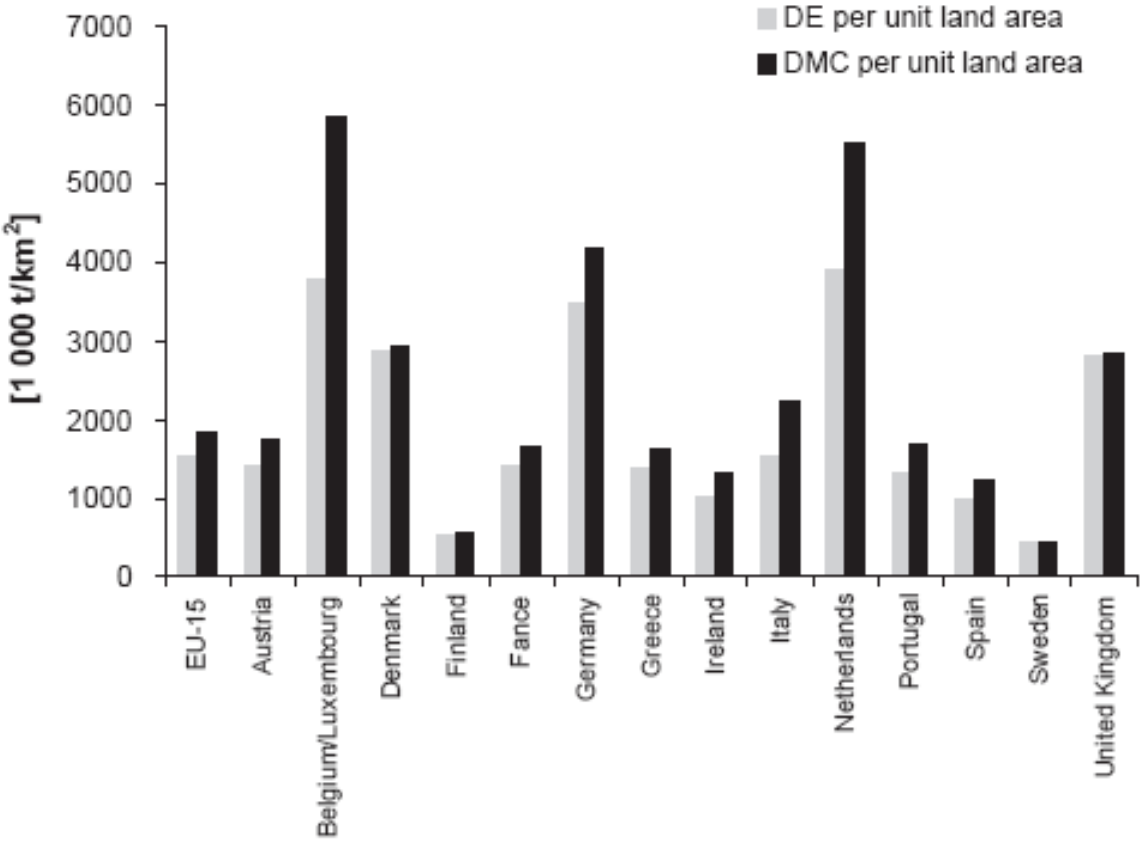
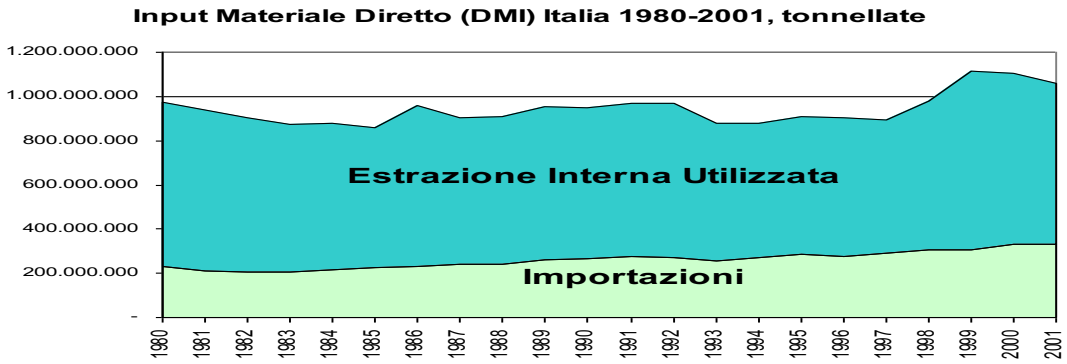


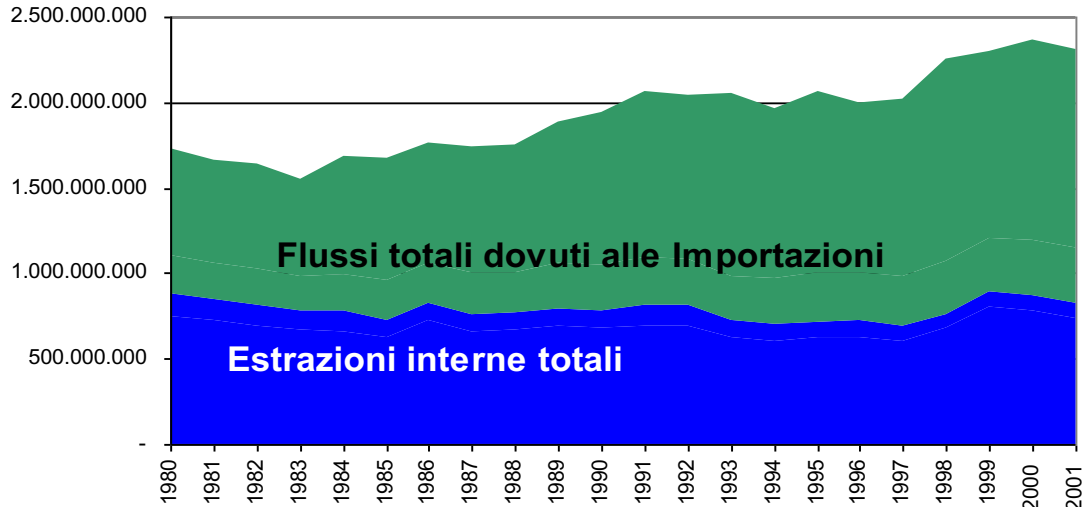


Composition of DMC per capita (2000)



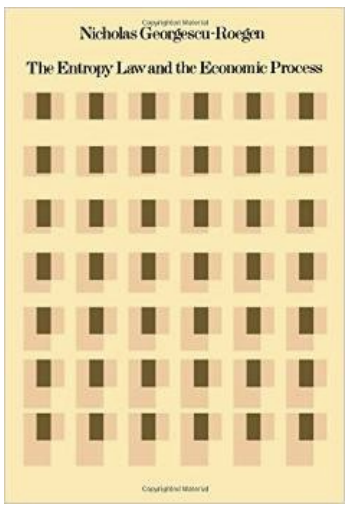
DMC e DE per unit of land area





Nicholas Georgescu-Roegen

Costanza, Romania, 1906 – Nashville, Tennessee,1994



First, the production of all instruments of war, not only of war itself, should be prohibited completely.
It is utterly absurd (and also hypocritical) to continue growing tobacco if, avowedly, no one intends to smoke.
The nations which are so developed as to be the main producers of armaments should be able to reach a consensus over this prohibition without any difficulty if, as they claim, they also possess the wisdom to lead mankind.
Discontinuing the production of all instruments of war will not only do away at least with the mass killings by ingenious weapons but
will also release some tremendous productive forces for international aid without lowering the standard of living in the corresponding countries.
Second, through the use of these productive forces as well as by additional wellplanned and sincerely intended measures, the underdeveloped nations must be aided to arrive as quickly as possible at a good (not luxurious) life. Both ends of the spectrum must effectively participate in the efforts required by this transformation and accept the necessity of a radical change in their polarized outlooks on life.

Third, mankind should gradually lower its population to a level that could be adequately fed only by organic agriculture.
level that could be adequately fed only by organic agriculture.
Naturally, the nations now experiencing a very high demographic growth will have to strive hard for the most rapid possible results in that direction.
Fourth,
until either the direct use of solar energy becomes a general convenience or controlled fusion is achieved,
all waste of energy
by overheating, overcooling, overspeeding, overlighting, etc.-
should be carefully avoided and if necessary, strictly regulated.
Fifth, we must cure ourselves of the morbid craving for extravagant gadgetry,
splendidly illustrated by such a contradictory item as the golf cart, and for such mammoth splendors as two-garage cars.
Once we do so, manufacturers will have to stop manufacturing such "commodities

Sixth, we must also get rid of fashion,
of "that disease of the human mind,"
as Abbot Fernando Galliani characterized it in his celebrated Della moneta (1750).
It is indeed a disease of the mind to throw away a coat or a piece of furniture
while it can still per form its specific service.
To get a "new" car every year and to refashion the house every other is a
bioeconomic crime.
Other writers have already proposed that goods be manufactured in such a way as
to be more durable
But it is even more important that consumers should reeducate themselves to
despise fashion.
Manufacturers will then have to focus on durability.
Seventh, and closely related to the preceding point, is the necessity that durable
goods be made still more durable
by being designed so as to be repairable.
To put it in a plastic analogy, in many cases nowadays, we have to throw away a
pair of shoes merely because one lace has broken.)

Eighth, in a compelling harmony with all
the above
thoughts we should cure ourselves of what
I have
been calling
«the circumdrome of the shaving
machine»,
which is to shave oneself faster
so as to have more time to work
on a machine that shaves faster
so as to have more time to work
on a machine that shaves still faster,
and so on ad infinitum.
[…]
We must come to realize that an important
prerequisite for a
good life is a substantial amount of leisure
spent in an
intelligent manner.

HOWEVER:
Will mankind listen to any program that implies a constriction
of its addiction to exosomatic comfort?
Perhaps, the destiny of man is to have a short, but fiery,
exciting and extravagant life
rather than a long, uneventful and vegetative existence.
Let other species – the amoebas, for example –
which have no spiritual ambitions
inherit an earth still bathed in plenty of sunshine.
Energy and Economic Myths, Nicholas Georgescu-Roegen, Southern Economic Journal, Vol. 41, No. 3 (Jan., 1975), pp. 347-381
Georgescu's MINIMAL BIOECONOMIC PROGRAM
Aim: down-sizing the material scale of the economy
IS THIS CATASTROPHISM?
NO … PRECAUTIONARY PRINCIPLE
... We'll see it soon!