Freight and Logistic

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Why Do We Care About Logistics?

(The Vital Role of Logistics)

🛡️ **Saving Lives**

•Starvation often results not from food shortages, but from poor distribution.

"Logistics saves lives." — François Bourguignon, Amartya Sen

🏙️ **Strengthening Communities**

•Critical for smart cities, resilience, education, businesses, and military operations.

•No general wins with starving soldiers!

🦠 **Lessons from COVID-19**

•Crisis revealed logistics bottlenecks:

  •Tests, masks, respirators, and vaccines were available — but not always accessible.

•Highlighted the **limitations** of just-in-time strategies and over-reliance on globalization.

🔄 **Adaptations Post-Crisis**

•Strategic production relocation

•Diversification of supply chains

•New focus on resilience over efficiency

🔄 **Automation** (production/transportation, and more!)

•ChatGPT, Bard,..→ jobs lost but also created : Who wins, who looses? (see Daron Acemoğlu, Joe Stiglitz,…)

Logistics

- Aim of Logistics: manage physical flows, and data (customs, transaction cost or financial) in order to match resources and needs
- Constraints: Financial, legal, institutional, environmental, minimum quality of services, and human. Coordination issues
- Objectives: optimize expected quality of service/products offered, while ensuring safety, security, reliability, and sustainability at minimum costs (difficulty to deal with uncertainty!)
- Technical Tools at the ground level: various operations research tools, IA
- Strategy in the short, medium and long run: locations of production units, warehouses, storage capacity, and choice of transport modes

Why do we care about logistic?

- Starvation is not due to the lack of food but to the lack of appropriate distribution: logistic saves lives (François Bourguignon, Amartya Sen).
- Logistic is an essential component for smart cities (& resilience), for firms, education, and armies (no good general has starving soldiers). Role of AI.
- CODIV-19 polices dependent on the availability of (1) tests, (2) masks, (3) respirators, and (4) vaccines. Such ingredients exist. Production, transportation, or distribution were not ideal: logistic could save lives. It has taught us that just in time, globalization, free trade have some limitations! After this crisis, logistic has been adapted: relocation of strategic production, diversification, etc.
- Sustainability issues, …..
- The silk road,…

Supply Chain Management (SCM)

- Supply Chain Management (SCM) is application of know-how aimed at implementation or at operational management.
- It involves the construction of a sequence and harmonization of tasks (as illustrated by the term “chain”), as well as the proper functioning of the logistics systems (determined by the logistics specifications of the organization)

See also: (OECD) International transport forum: https://www.itf-oecd.org/

The main Supply Chain Management areas

There are 7 primary functional areas:

1) Purchasing,
2) Manufacturing,
3) Inventory Management,
4) Demand Planning,
5) Warehousing,
6) Transportation, and
7) Customer Service

References

Suggested main text (classics)

Ghiani, G., Laporte, G., & Musmanno, R. (2022). Introduction to Logistics Systems Management: With Microsoft Excel and Python Examples. John Wiley & Sons.

Extra reading!

Tseng, Y. Y., Yue, W. L., & Taylor, M. A. (2005). The role of transportation in logistics chain. Eastern Asia Society for Transportation Studies.

For urban logistics/economics (more economics): Krugman, P. R. (1991). *Geography and Trade*. MIT Press.

What is the impact of regional and international trade on GNP?

- Autarky (backyard economy)←→protectionism←→full globalization
- “Globalization” means that some jobs are lost and others are created.
- Gains from trade in the US (a few % of GNP). Larger in smaller countries (e.g. Belgium).
- Transport cost [iceberg costs] is a key aspect in international trade and location theory {see also Hakimi Theorem}. What about external costs?
- Logistic aspects are usually forgotten in economic models, but economics studies the gains of trade (and the welfare loss of tariffs)

Why do countries trade?
Law of comparative advantages

- Gains from trade: the **Law of Comparative Advantages** (David Ricardo, 1817) →Specialization in the products with the largest *relative* advantages
- David Ricardo demonstrated how England and Portugal could both benefit by specializing and trading according to their comparative advantages. (see next slide)
- Trade is beneficial even when one country is less efficient at producing each good.
- In this scenario, Portugal could produce wine at a lower cost, while England was more efficient at manufacturing cloth. Accordingly, Portugal should specialize in wine and England in cloth.
- But a State may wish to protect emerging industries.

Ricardo's Original Example (1817) Ricardo compared….

England and **Portugal** producing **cloth** and **wine**.

Country	Labor hours to produce 1 unit of Cloth	Labor hours to produce 1 unit of Wine
England	100 hours	120 hours
Portugal	90 hours	80 hours

Interpretation:

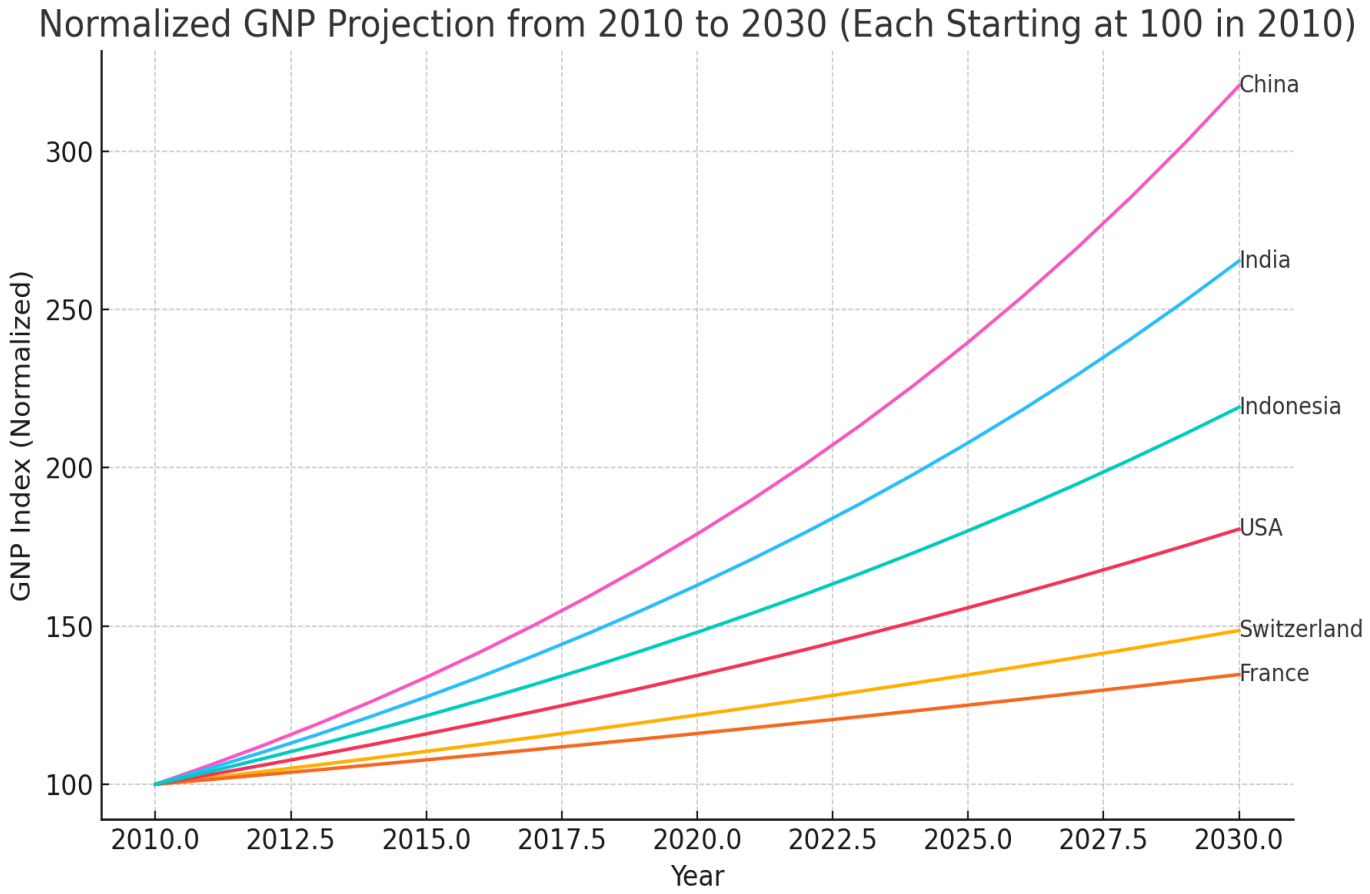
- **Portugal** is more efficient at producing **both** cloth and wine (needs fewer hours).
- But **comparative advantage** is about **relative** costs:
  - In England: 1 unit of wine = 1.2 units of cloth (because cloth needs 100 hours per unit).
  - In Portugal: 1 unit of wine = 0.89 units of cloth (because cloth needs 90 hours per unit).

Thus: the **relative price of wine** (in terms of cloth) is higher in England than in Portugal — meaning England should specialize in cloth and Portugal in wine.

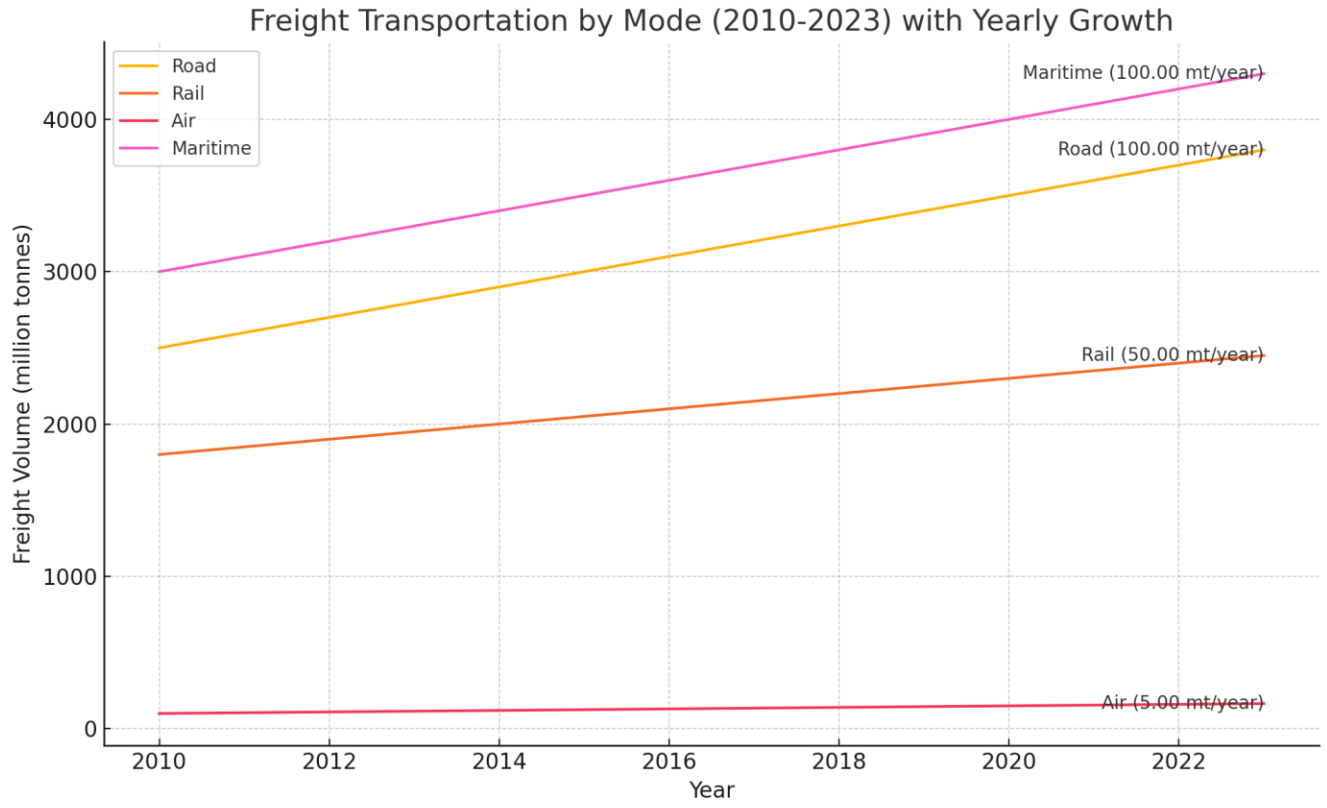
- **Portugal** has a **comparative advantage in wine**. Portugal should only produce wine
- **England** has a **comparative advantage in cloth**. England should only produce cloth

Each country should specialize and **trade**!

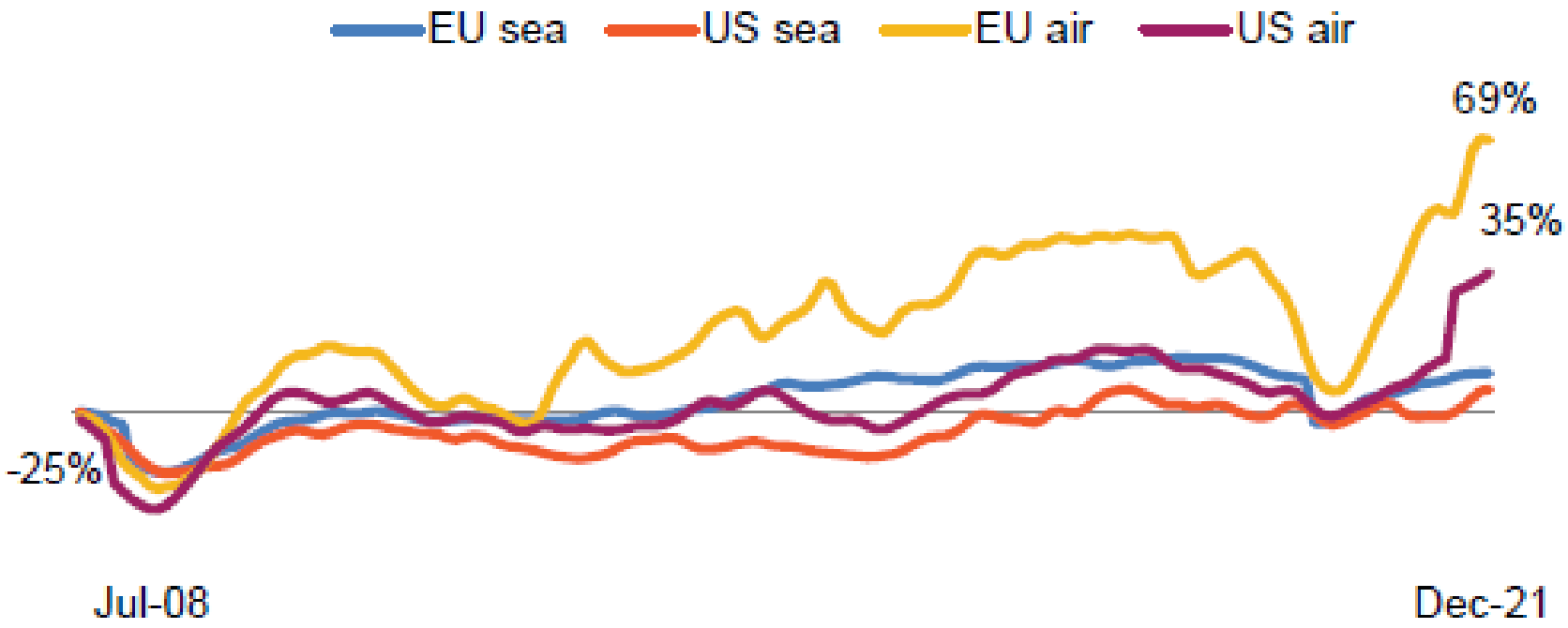
GNP growth (World Bank, IMF, PwC)



Freight transportation increases for all modes. (All energy consumptions increase, J.B. Fressoz)



International trade by sea and air, % change



Source: International Transport Forum.

(.) International Transport Forum: 2021 data

- Increase in freight transport in 2021. Global economy started to recover from the Covid-19 pandemic in 2021.
- The global GDP increased by **6.1%** between 2020 and 2021: 6.8% in emerging and developing economies; 5.2% in the advanced economies.
- World trade volume increased by **9.8%**
- Air freight ton-kilometers by **18.7%** between 2020 and 2020.

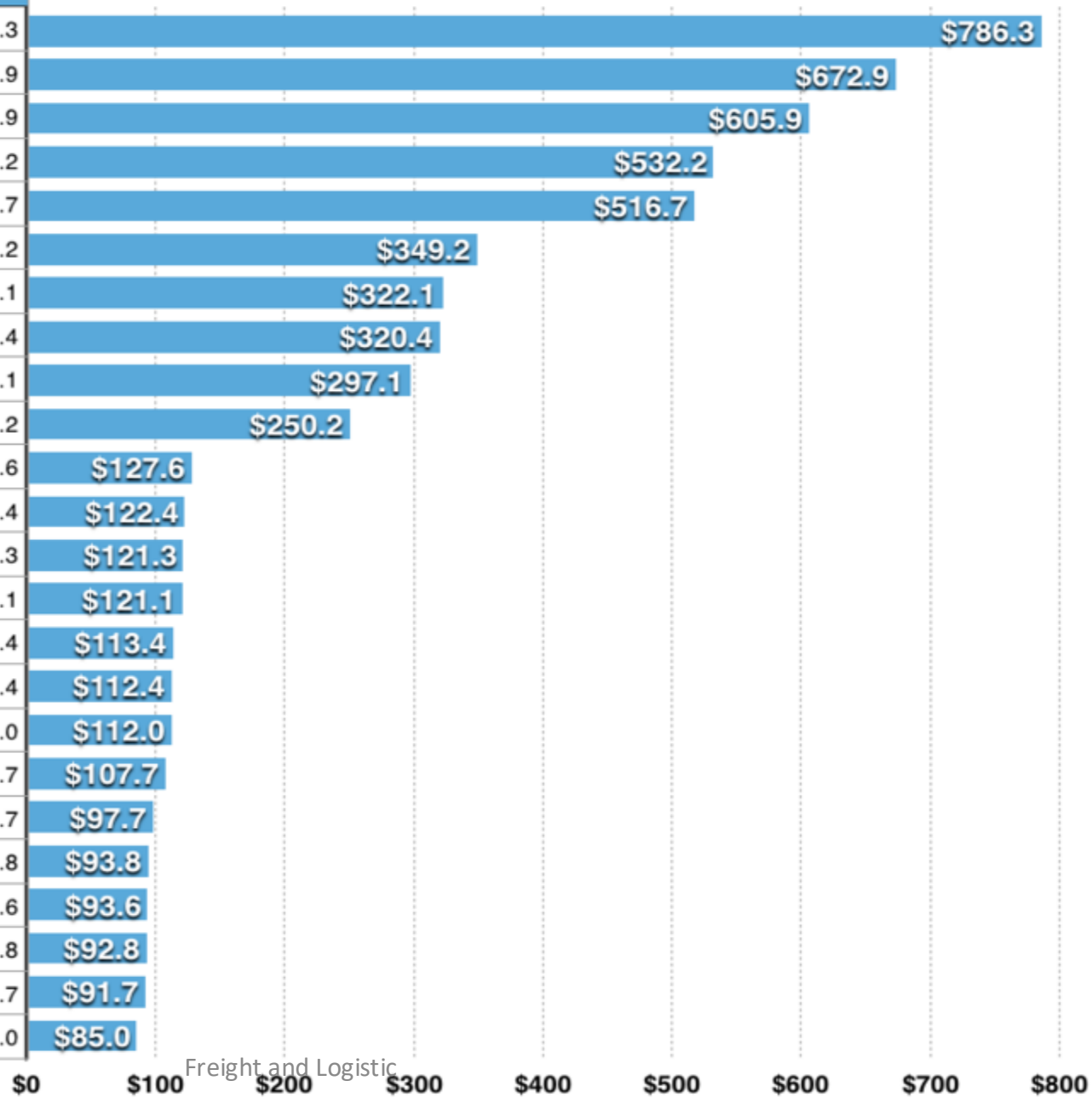
This is mainly the result of the big impact of Covid-19 especially on the air freight sector during 2020.

- Surface freight transport was hit less than air transport during the pandemic

--Rail freight increased of **8.2%** and **6.4%** in the EU and in USA, respectively. ---Road freight tons-kilometers also increased by **6.5%** in EU.

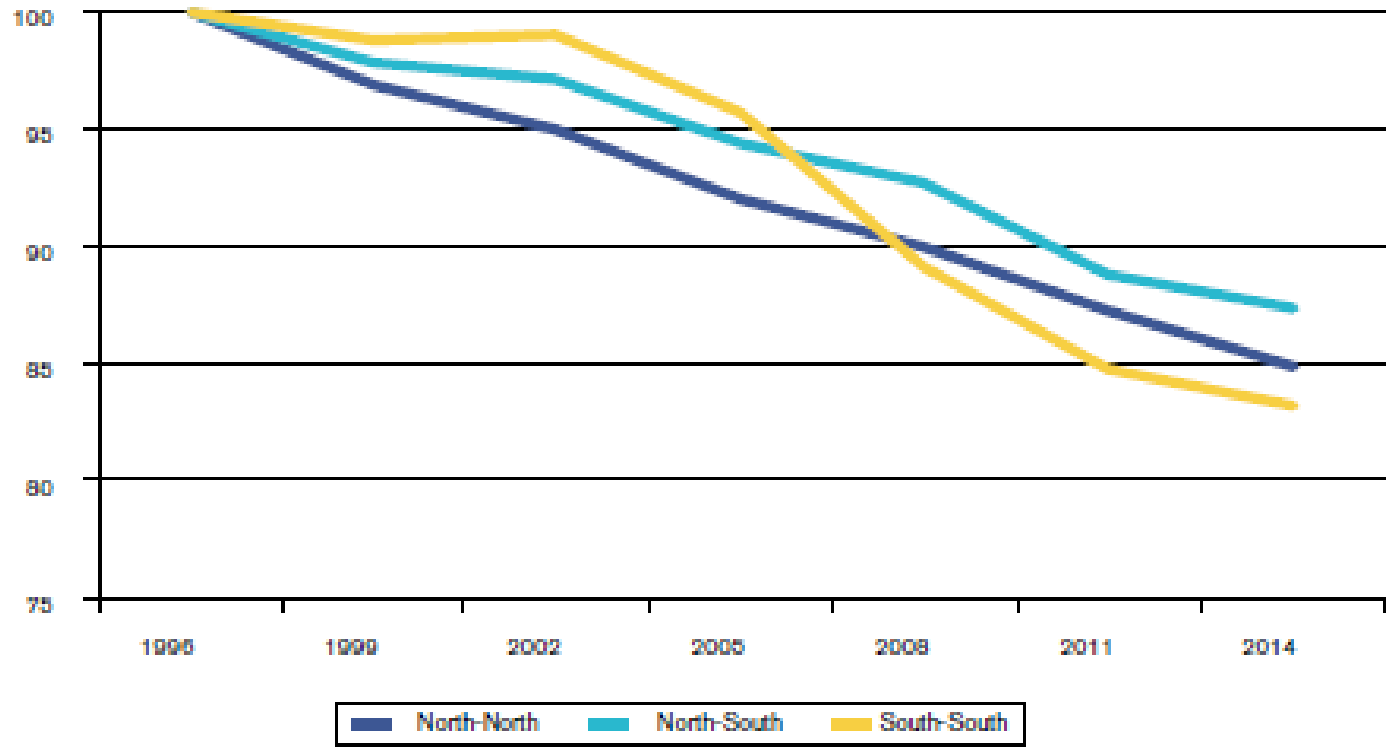
Global exports by product 2015 ($Billions)

Product Name	2015 Export Sales
Crude oil	$786.3
Cars	$672.9
Processed petroleum oils	$605.9
Phone system devices	$532.2
Integrated circuits/microaccemblies	$516.7
Automobile parts/accessories	$349.2
Medication mixes in dosage	$322.1
Computer, optical readers	$320.4
Gold (unwrought)	$297.1
Petroleum gases	$250.2
Blood fractions (including antisera)	$127.6
Aircraft, spacecraft	$122.4
Computer parts, accessories	$121.3
Diamonds	$121.1
Trucks	$113.4
Insulated wire/cable	$112.4
Solar power diodes/semi-conductors	$112.0
Electro-medical equipment	$107.7
Jewelry	$97.7
Printing machinery	$93.8
Lower-voltage switches, fuses	$93.6
Tv receivers/monitors/projectors	$92.8
Electrical converters/ power units	$91.7
Liquid crystal/laser/optical tools	$85.0



Trade costs decrease over time!→More trade implies more competition! "*The future of word trade and digital technologies report*"

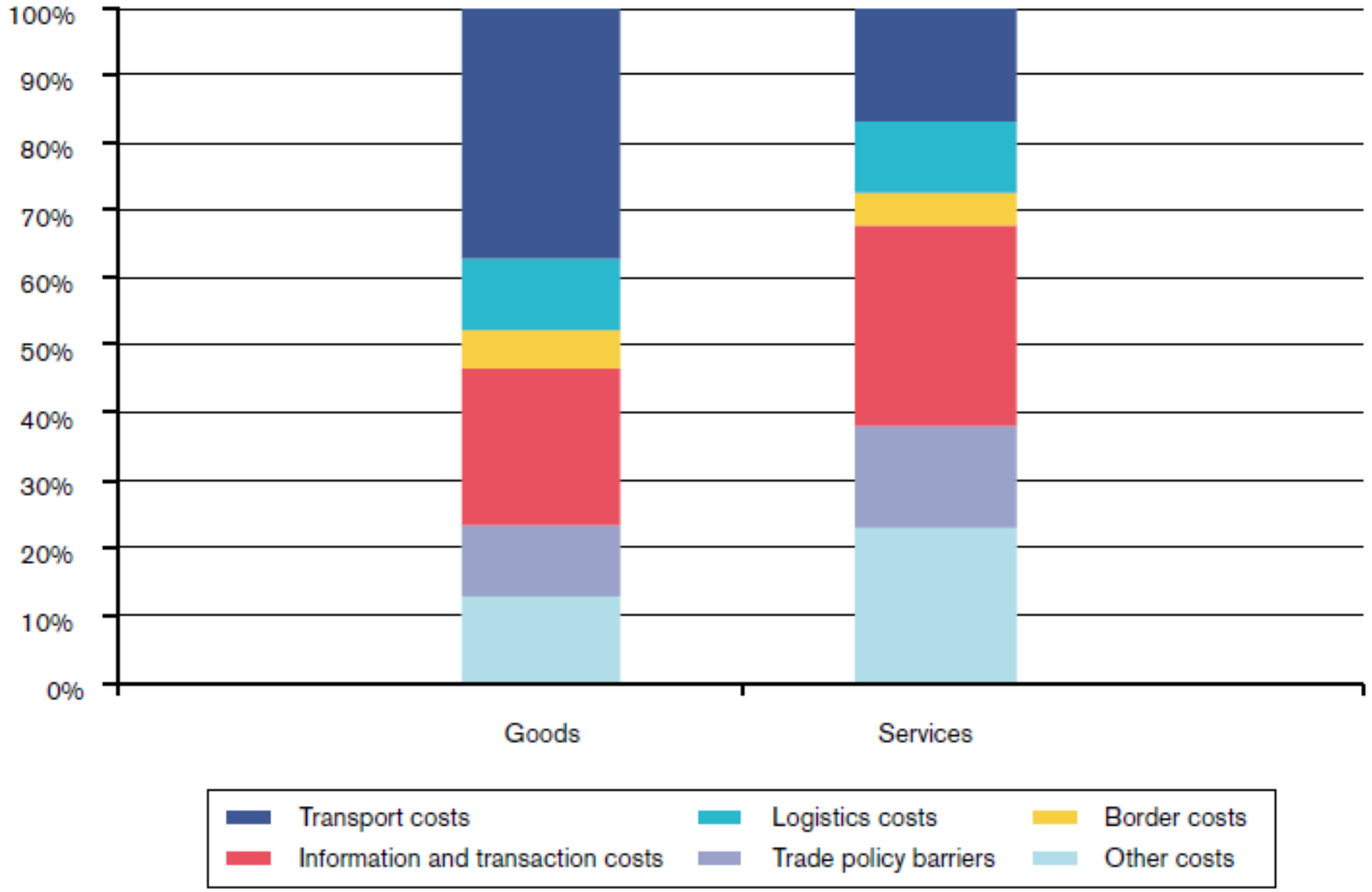
Figure C.1: Overall trade costs, 1996-2014



Source: World Bank-ESCAP database on International trade costs.

Notes: Only those country pairs for which data were consistently available for the years 1996-2014 have been included, i.e. 107 countries that were classified as developed (high-income) and developing (middle-/low-income) based on the World Bank classification for the year 2006, which is the midpoint of the time series. Each time series is standardized to 100 at the beginning of the sample period.

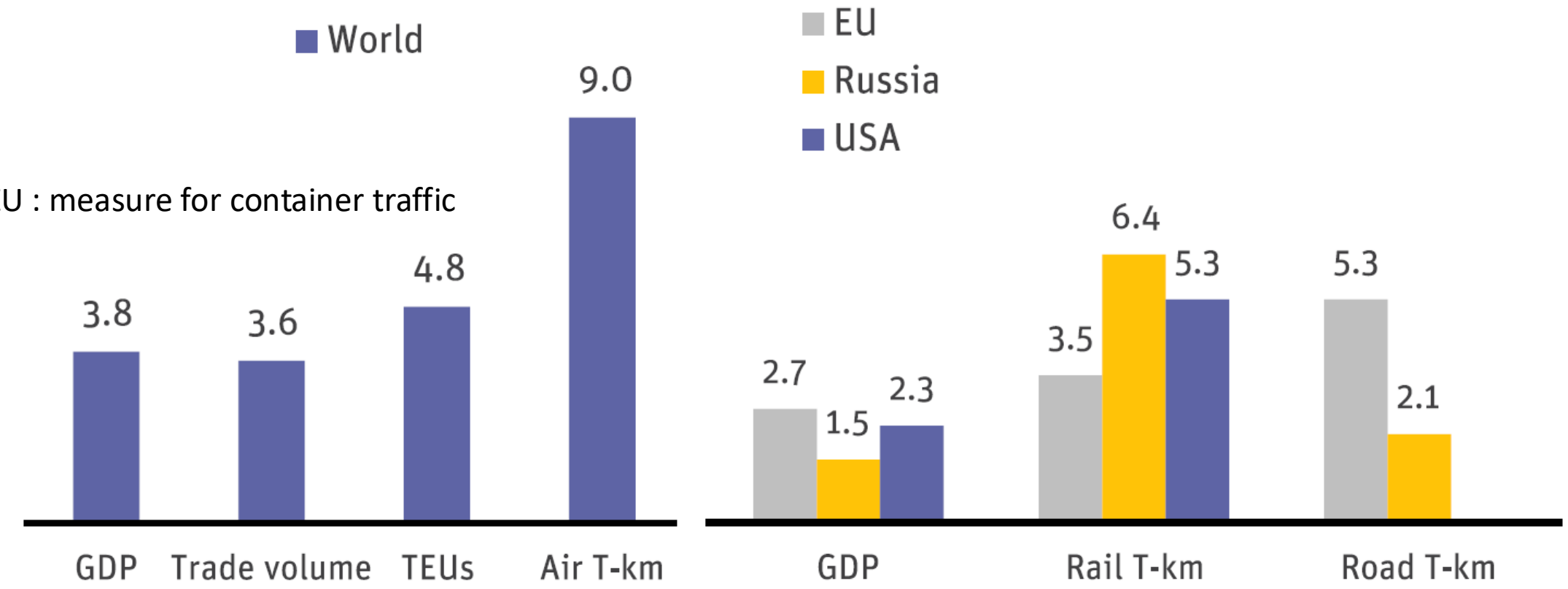
Figure C.2: Trade costs breakdown, based on data from 2014 (per cent)



Source: WTO calculations using World Input-Output Database (WIOD) data and methodology from Chen and Novy (2011).

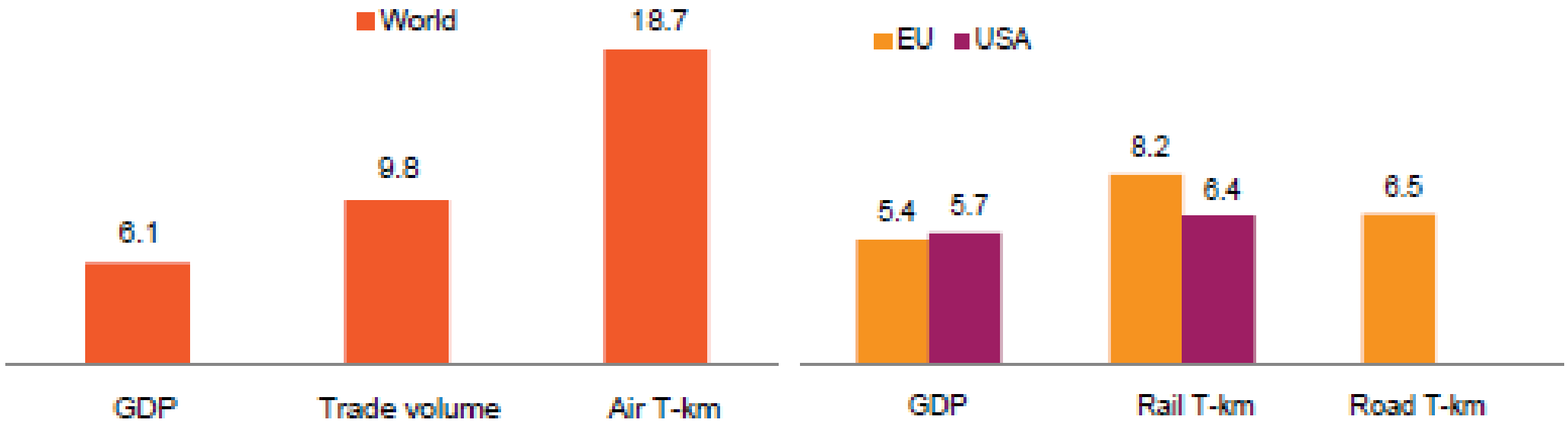
GDP, trade and freight transport in 2017 (% change from the previous year)

TEU : measure for container traffic



Sources: International Transport Forum, except world GDP (IMF), trade volume (WTO), world container traffic (Clarksons Research), air T-km (IATA). Note: EU rail T-km coverage (BEL, GRC and MLT not included. AUT, DEU and ISR 3 quarters). Road T-km coverage (DEU, IRL, ITA, MLT, and GBR not included. AUT, BEL, GRC, and LUX 3 quarters). Road T-km in Russia includes only national.

GDP, trade and freight transport in 2021 (% change from the previous year)



Sources: International Transport Forum, except world GDP (IMF), trade volume (WTO), air T-km (IATA). Note: EU rail T-km coverage (BEL and MLT not included. FIN 3 quarters). EU road T-km coverage (BEL, GRC, ITA, MLT and ROU not included. AUT, DEU, IRL, LUX, NLD and SVK 3 quarters).

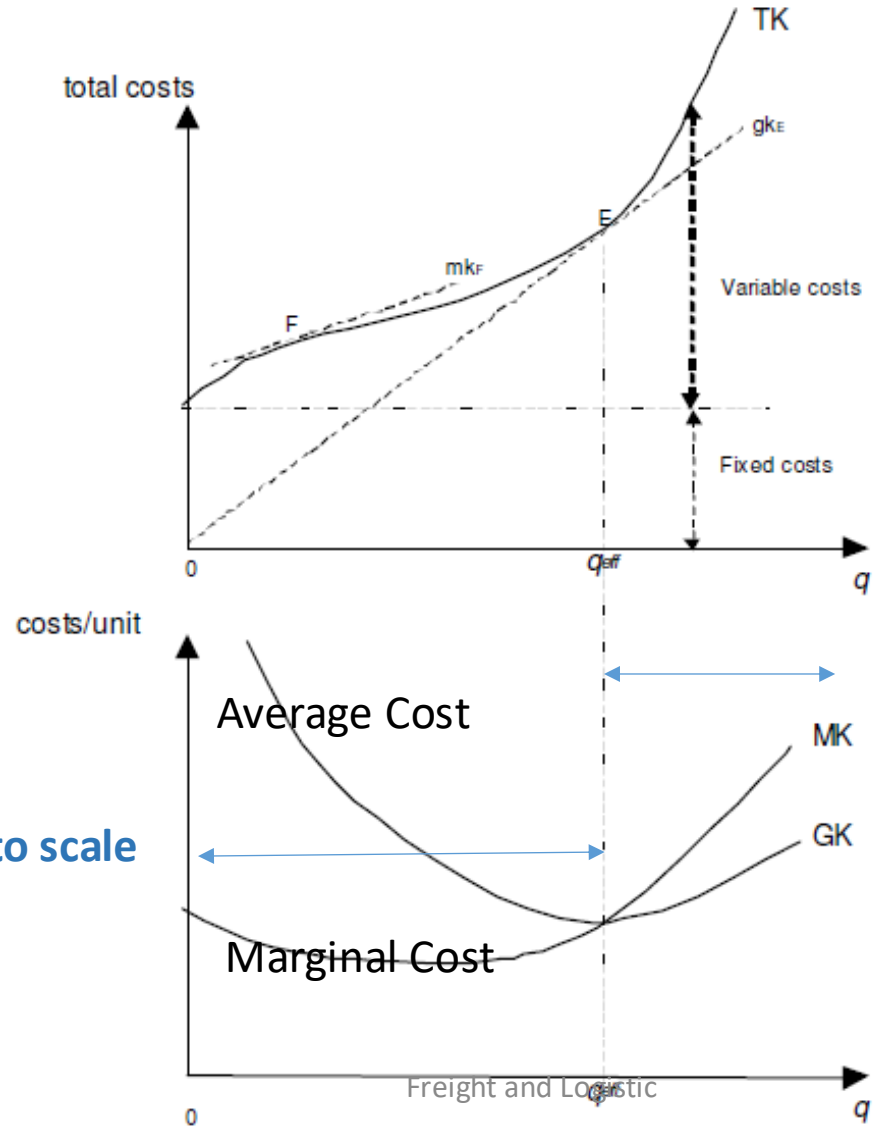
Cost categories of a Logistic system

- Definition: examples later on

- Fixed costs
- Variable cost
- Scale, scope, network economies
- Indivisibilities (production, storage, distribution)

Economy of scale: geometry

TK: Total cost
MK: Marginal cost
GK: Average cost



Decreasing returns to scale

Increasing returns to scale

Economy of scale: formula

One product. S=: inverse of cost elasticity w.r.t production.

S>1: “increasing returns” to scale, Marginal Cost < Average Cost

S<1, “decreasing returns” to scale, Marginal Cost > Average Cost

S=1: “constant return” to scale, where **S** defined by:

$$S \equiv \left[\frac{dC}{dy}\frac{y}{C}\right]^{-1} = \left[\frac{dC/dy}{C/y}\right]^{-1} = \frac{C/y}{dC/dy} = \frac{Average\ Cost}{Marginal\ cost}$$

Economy of scope

- Cost of joint production C=C(y_1,y_2).
- The cost of separate production are then: C=C(y_1,0) and C=C(0,y_2). Let:

$$S_{scope} = \frac{C(y_1,0) + C\left(0,y_2\right) - C\left(y_1,y_2\right)}{C\left(y_1,y_2\right)}$$

$$S_{scope} > 0 \text{ Positive scope economy}$$

$$S_{scope} < 0 \text{ Negative scope economy}$$

Import / export: why?

- Why apples are imported from Belgium to France and others from France to Belgium? Etc.

Because product differentiation!

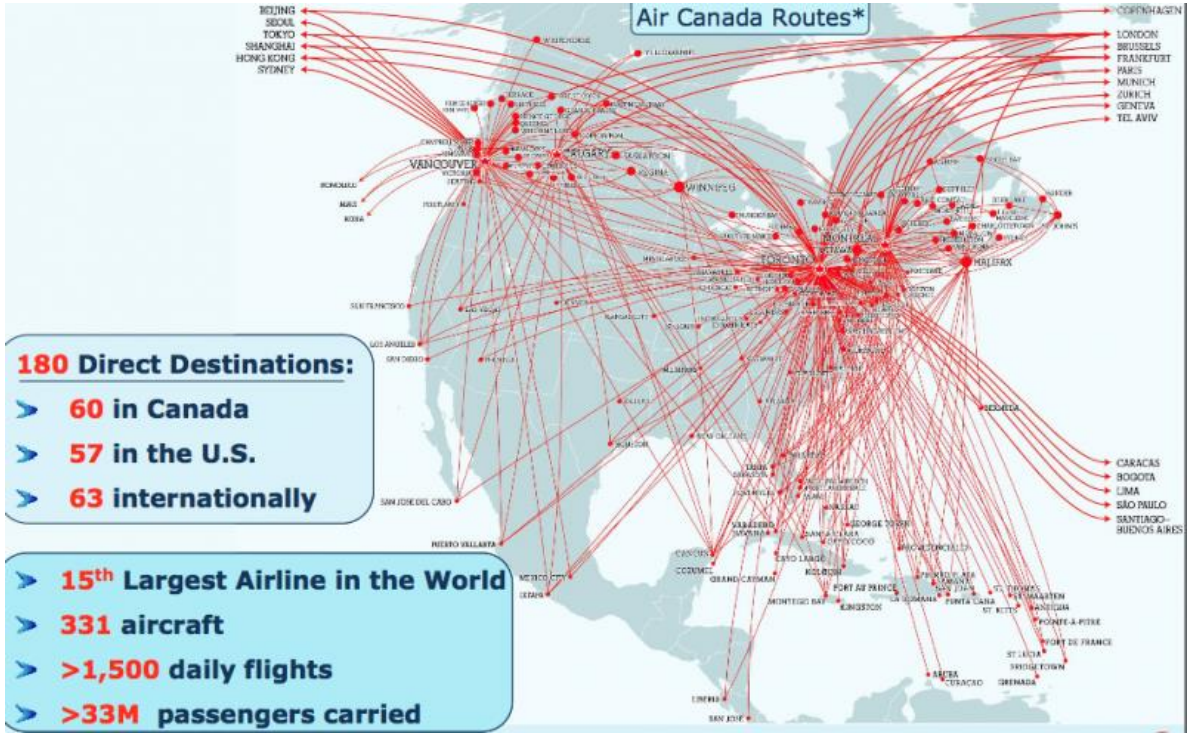
→ Individual *i* has some proba. $P_i(j)$ to purchase a good at location *j*

Let: $U(k)=V(k)-p(k)-d(i,k))+ \mu \varepsilon_k$, $k=1,..,n$,where ε_k are i.i.d. Gumbel random variables; μ: product differentiation:

$$P_i(j)=\exp[(V(j)-p(j)-d(i,j))/\mu]/\{\Sigma_{k=1,\ldots,n}\exp[(V(k)-p(k)-d(i,k))/\mu]\}$$

- $P_i(j)$ is a decreasing function of d(i,j) (to be drawn).

Economy of network size:
unit costs decrease with the size of the transportation network
Hub and spoke systems (pro and con)



→Alliance: Air France and KLM

Traffic control

- Adler, N., Hanany, E., & Proost, S. (2022). Competition in congested service networks with application to air traffic control provision in Europe. *Management Science*, *68*(4), 2751-2784.

The economics of platforms

- The **platform** facilitated economic and social activities.
- Platforms aims to bring supply and demand together, to "match" them.
- **Platforms** are typically online matchmakers / technological frameworks Airlines hubs, BlablaCar, taxis or Uber (& Amazon, TV, radio, Meetic)

→Multiple equilibria (research on Uber with G. Monchambert, Uni Lyon)

- “Despite the obvious efficiency gains generated by platform intermediation, the last few years have witnessed a renewed concern about its impact on consumer welfare. The pricing practices in platform markets raise a number of challenges to economic theory and competition policy.” Jean Tirole, TSE
- The most common types are "transaction platforms", (digital systems that connect different groups, buyers and sellers, drivers and passengers, hosts and guests,), also known as "digital matchmakers".

Two-sided market, or two-sided networks

- Old version: Negative and Positive network externalities
- New version : t**wo-sided market**, or **two-sided** networks: intermediary **economic platform** have **two** distinct user groups that provide each other with network benefits. ...
- **Two-sided markets** are particularly useful for analyzing the chicken-and-egg problem of standards economic battles.

End of economic break

Competition between VHS and Beta: the ‘best’ technology may loose!

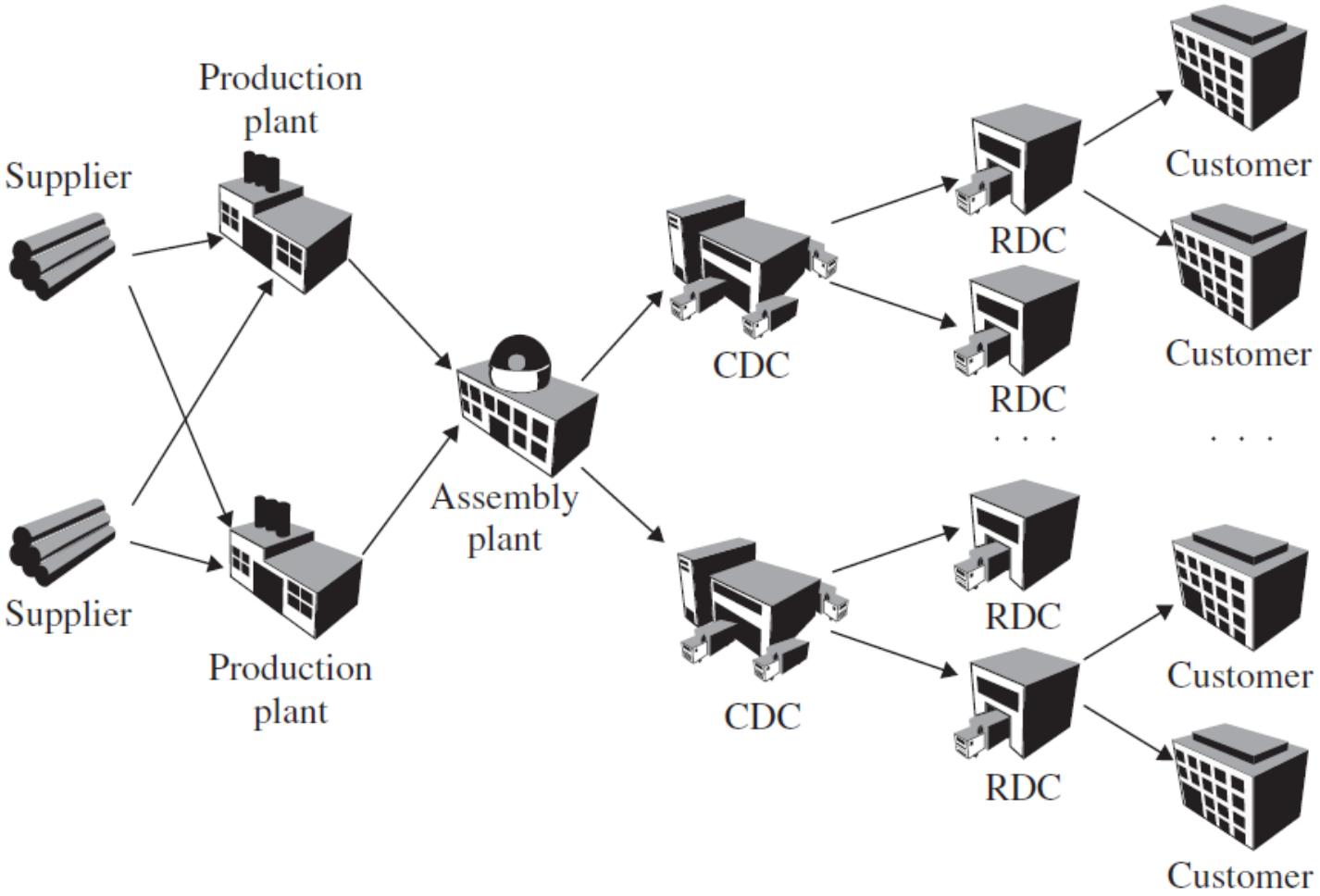
•**Betamax** was actually **technically better** than VHS. It had **higher picture quality** and **better durability**.
•However, **VHS won the market** and became the global standard.
Why did VHS win even though Beta was "better"?
•VHS allowed **longer recording time** (initially 2 hours, enough for a full movie).
•VHS was **cheaper** and **more widely licensed** to manufacturers, making it **more affordable and available**.
•**Network effects** kicked in: more people had VHS, so more movies were released on VHS,
•which made even more people choose VHS.
Main lesson:
In markets where **network effects** and **user adoption** matter (especially platforms and technologies), **the technically best product doesn't always win**. **Accessibility, marketing, partnerships, and user convenience** can be more important than pure technical superiority.
Would you also like me to show how this idea connects to platform strategies today (like Apple vs Android)?

Terminology

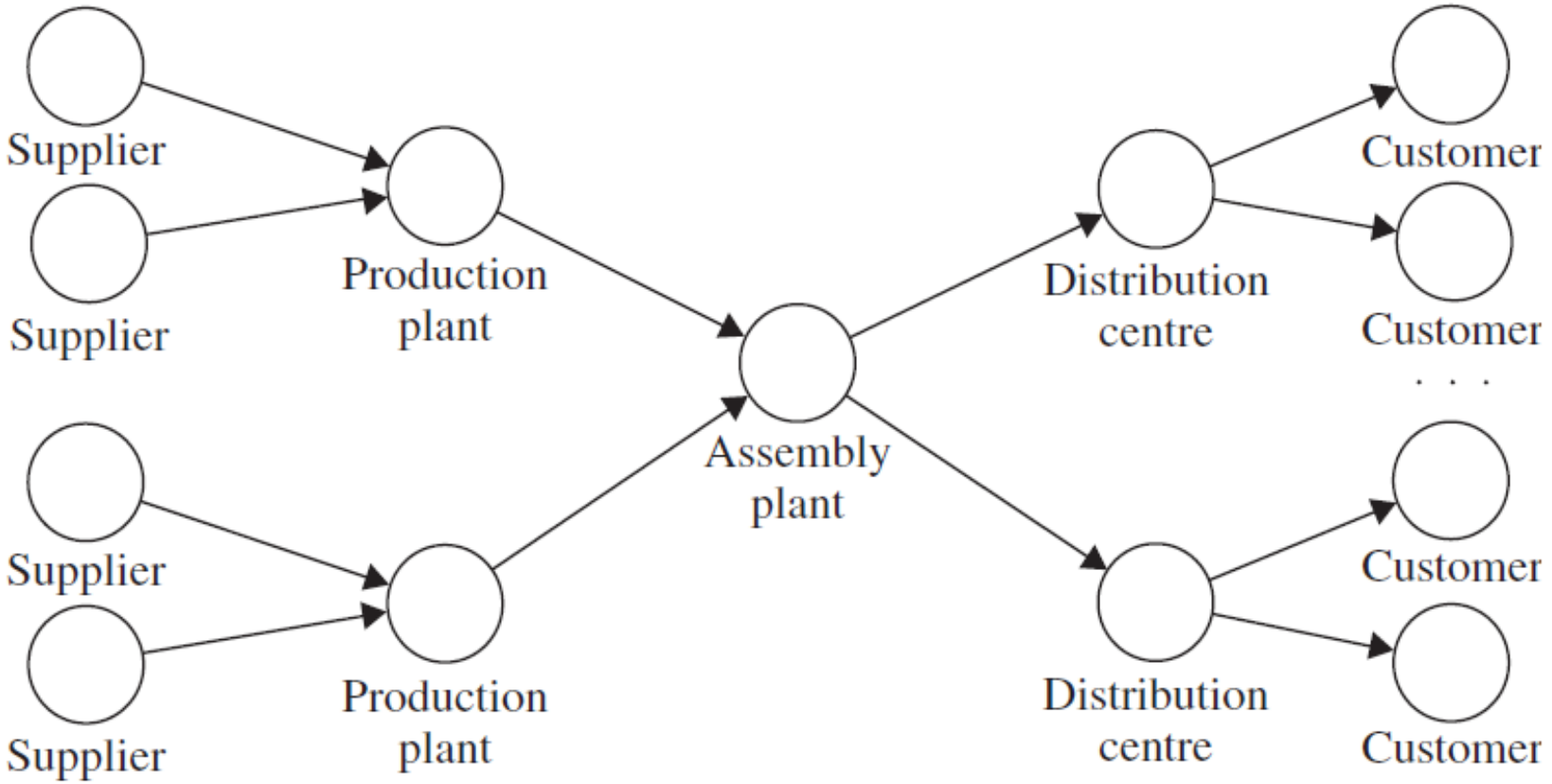
- CDC: Central Distribution Center
- GOD: Great Organized Distribution (e.g. food) [grande distribution organisée]
- RDC: Regional Distribution Center
- F.O.B. : Free on board
- CIF : Transport cost, Insurance and Freight
- Ad valorem (“according to value tax”): VAT or Value Added Tax is an ad valorem tax, e.g. 20% of the net price of the good.
- “Iceberg cost” : used in academia for general equilibrium models
- Quota: constraint of the quantity (e.g. number of cars) that can be imported

A Logistic System

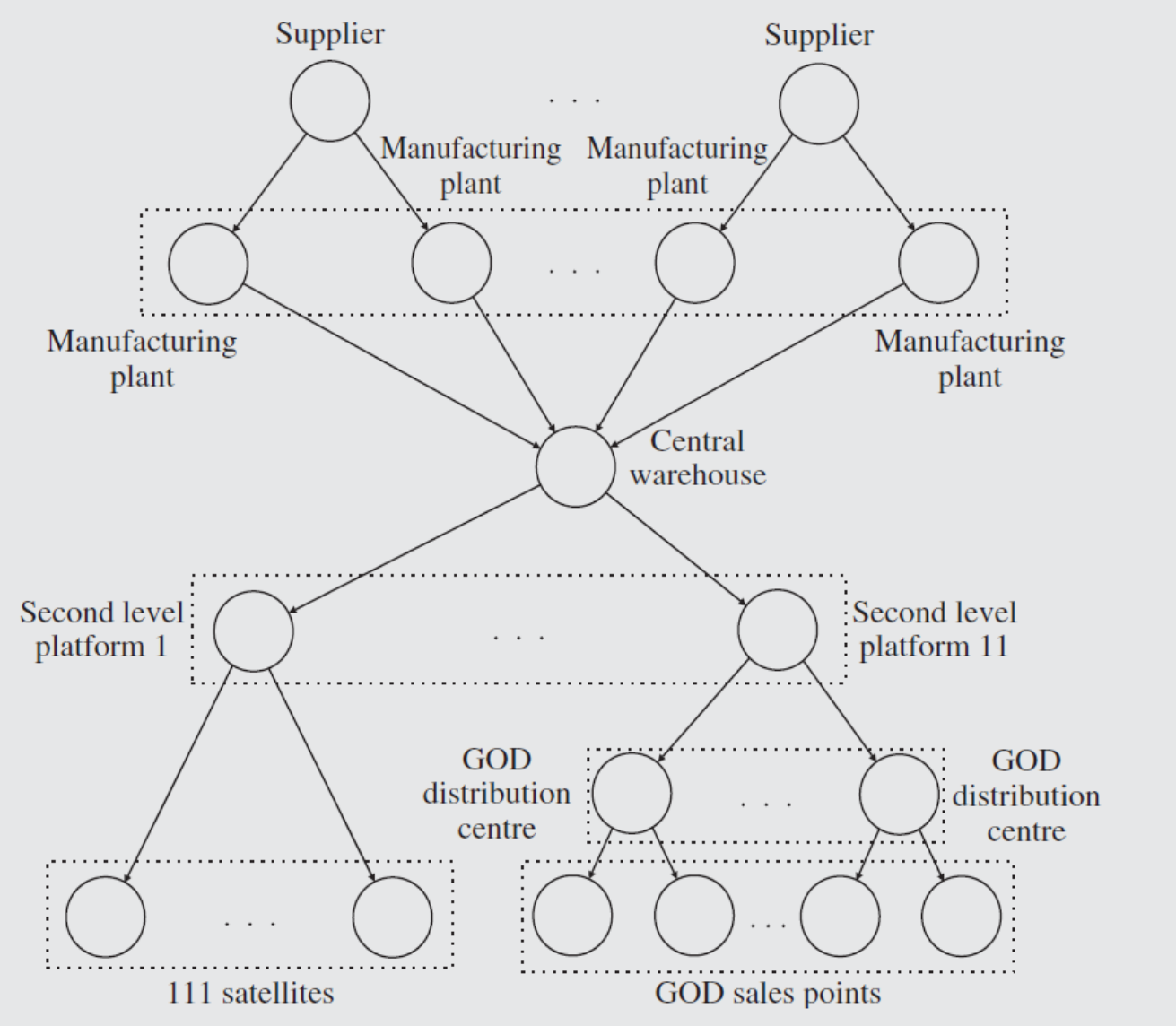
CDC: Central distribution centers
RDC: Regional Distribution Centers



Representation of a Logistic system by a directed graph (simplified)



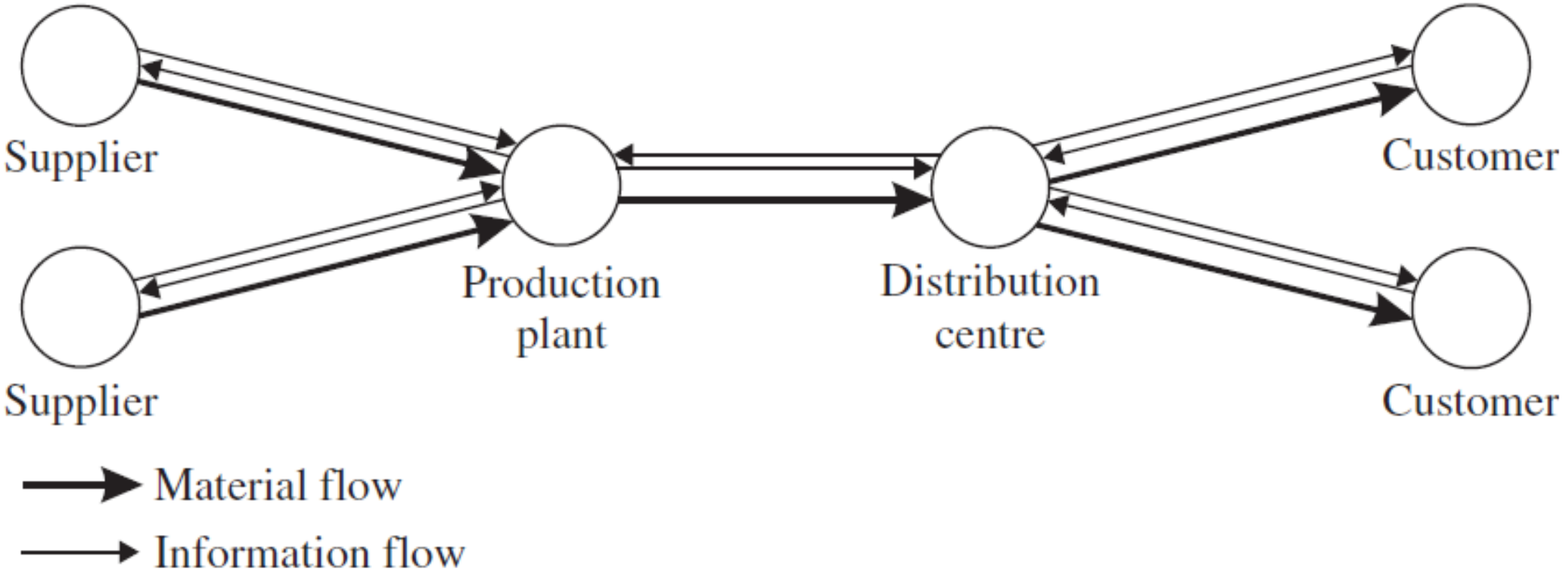
Logistic system : example of Galbani (Italy)



Satelites: small local distribution points close to final customers

GOD: Great Organized Distribution

A Logistic Network



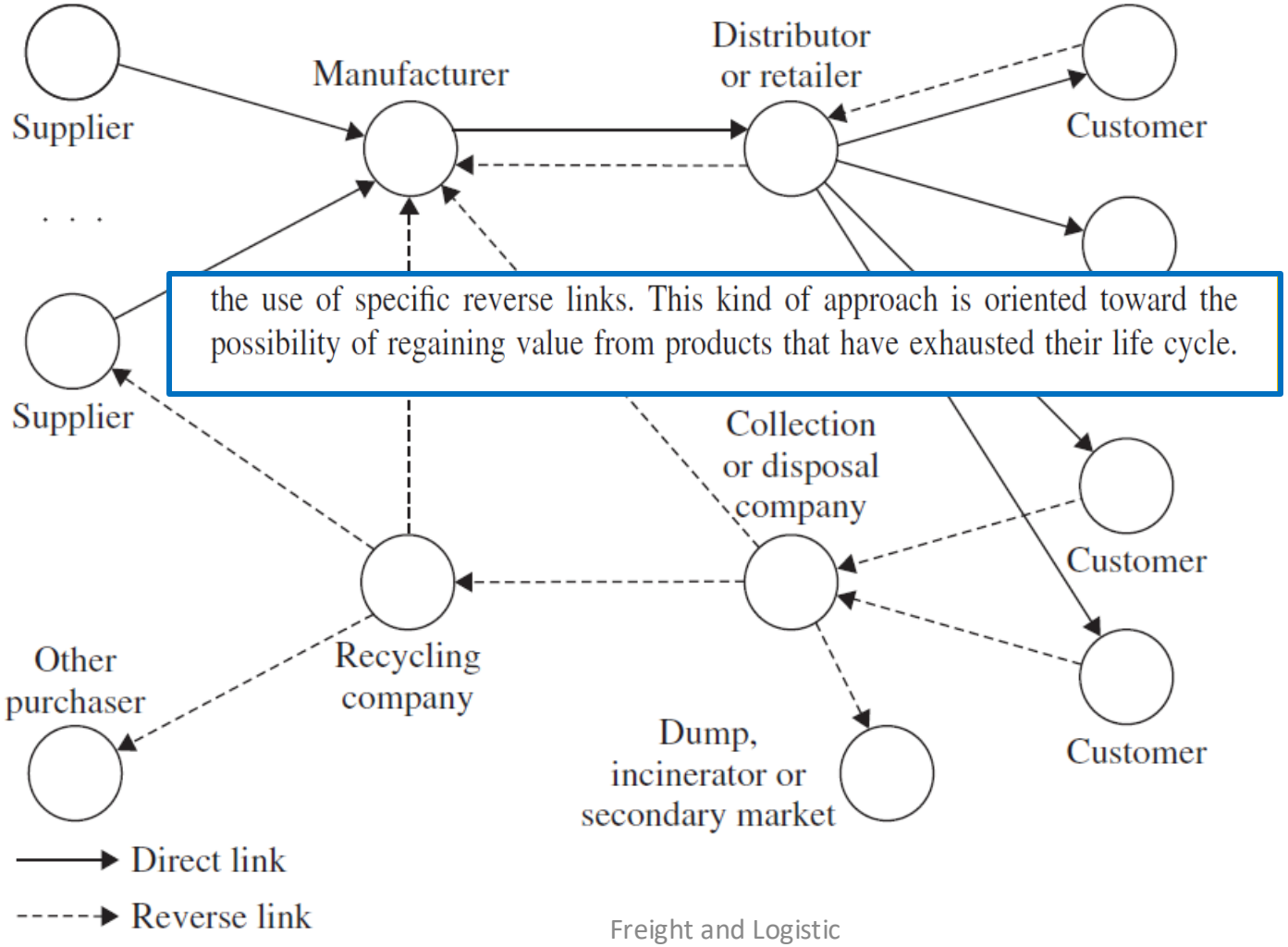
Reverse logistics: definition

- “Reverse Logistic” or “return logistics”:

→ Managing and optimizing flows from consumers to manufacturers

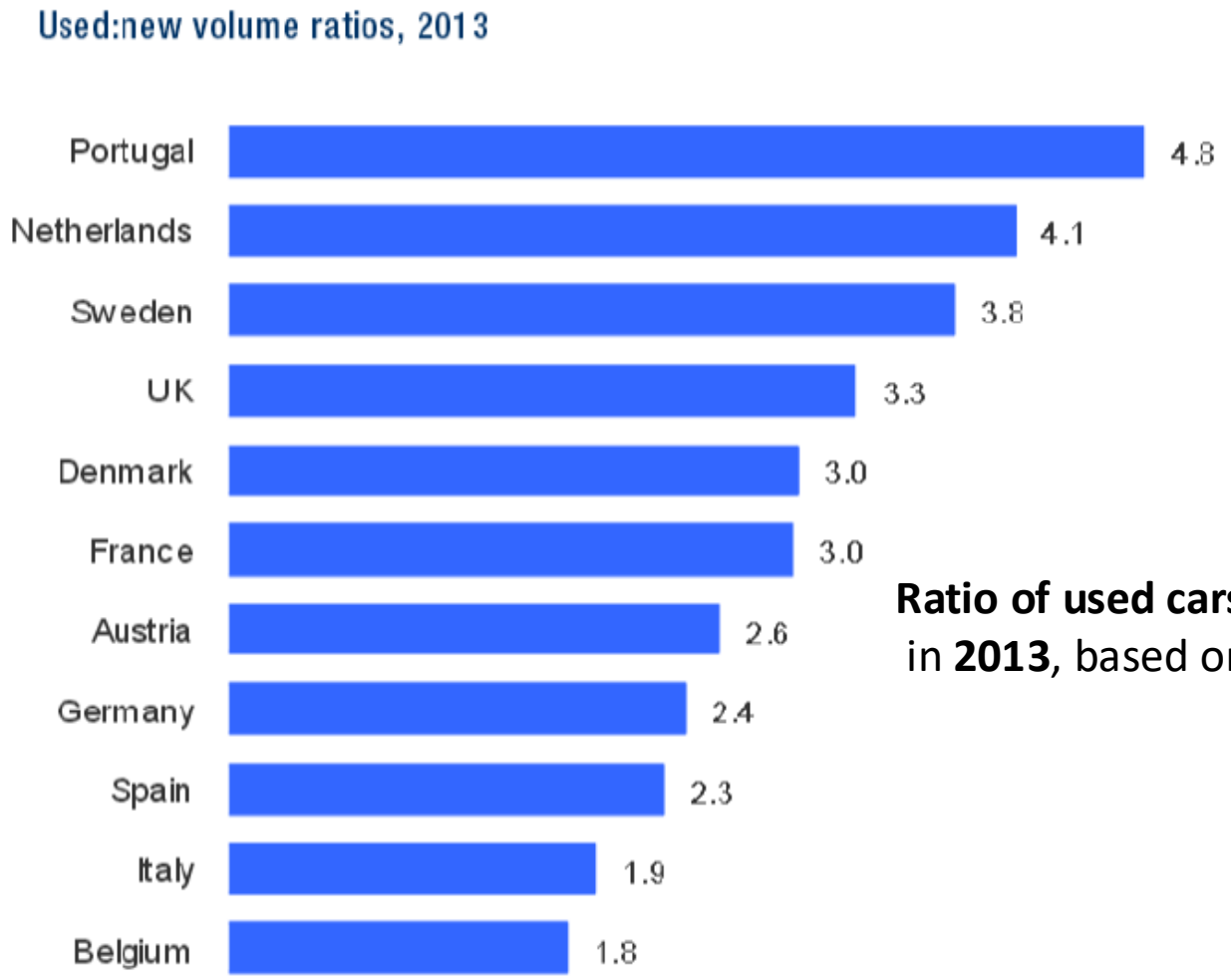
- Its most well-known form is that of After Sales Service, but it tends to develop towards recycling (Green concerns) and more particularly that of WEEE (Waste Electrical and Electronic Equipment).
- Return of defective products, overstocks or end-of-life items are also closely related to it, repair,…
- Example 1: Regain value form product that have exhausted their life cycle (issue also of programmed obsolescence)
- Example 2: second hand cars
- (Example 3: retrofitting of thermic engines into EV, of batteries),

Reverse Logistic system : example 1



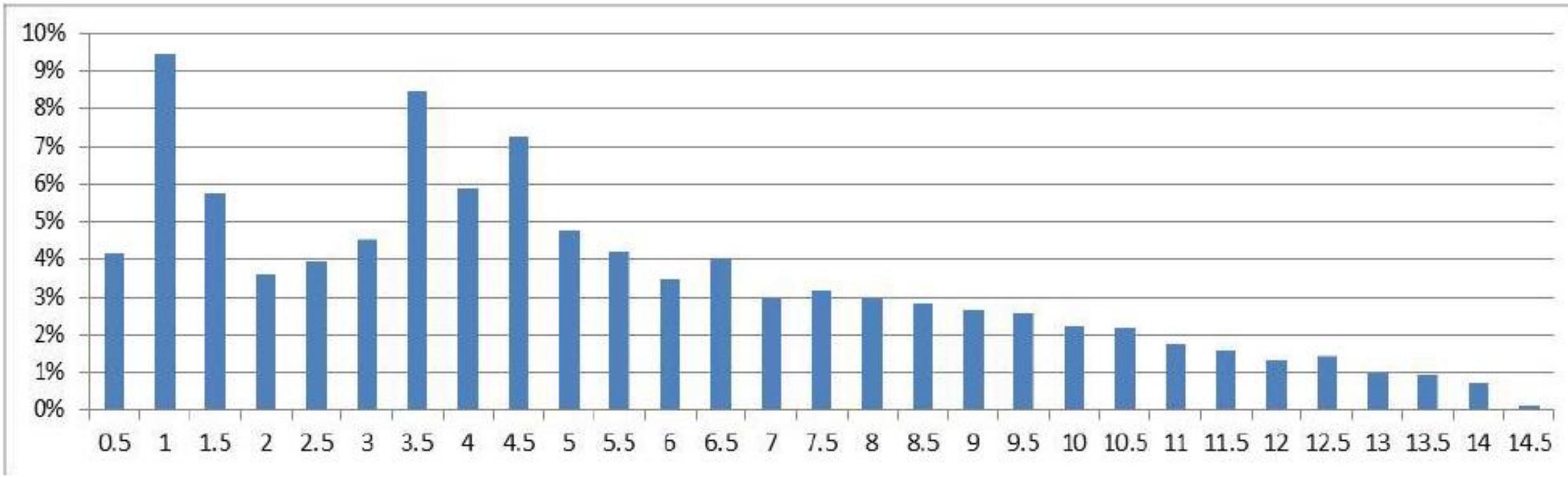
the use of specific reverse links. This kind of approach is oriented toward the possibility of regaining value from products that have exhausted their life cycle.

Second hand car: example 2



Ratio of used cars to new cars sold in different countries in **2013**, based on data from **ACEA National Trade Bodies**.

Source: ACEA/ National Trade Bodies



The distribution of the age of second hand cars, cleaned database (per 0.5 year)

Source: Transport Mobility Leuven

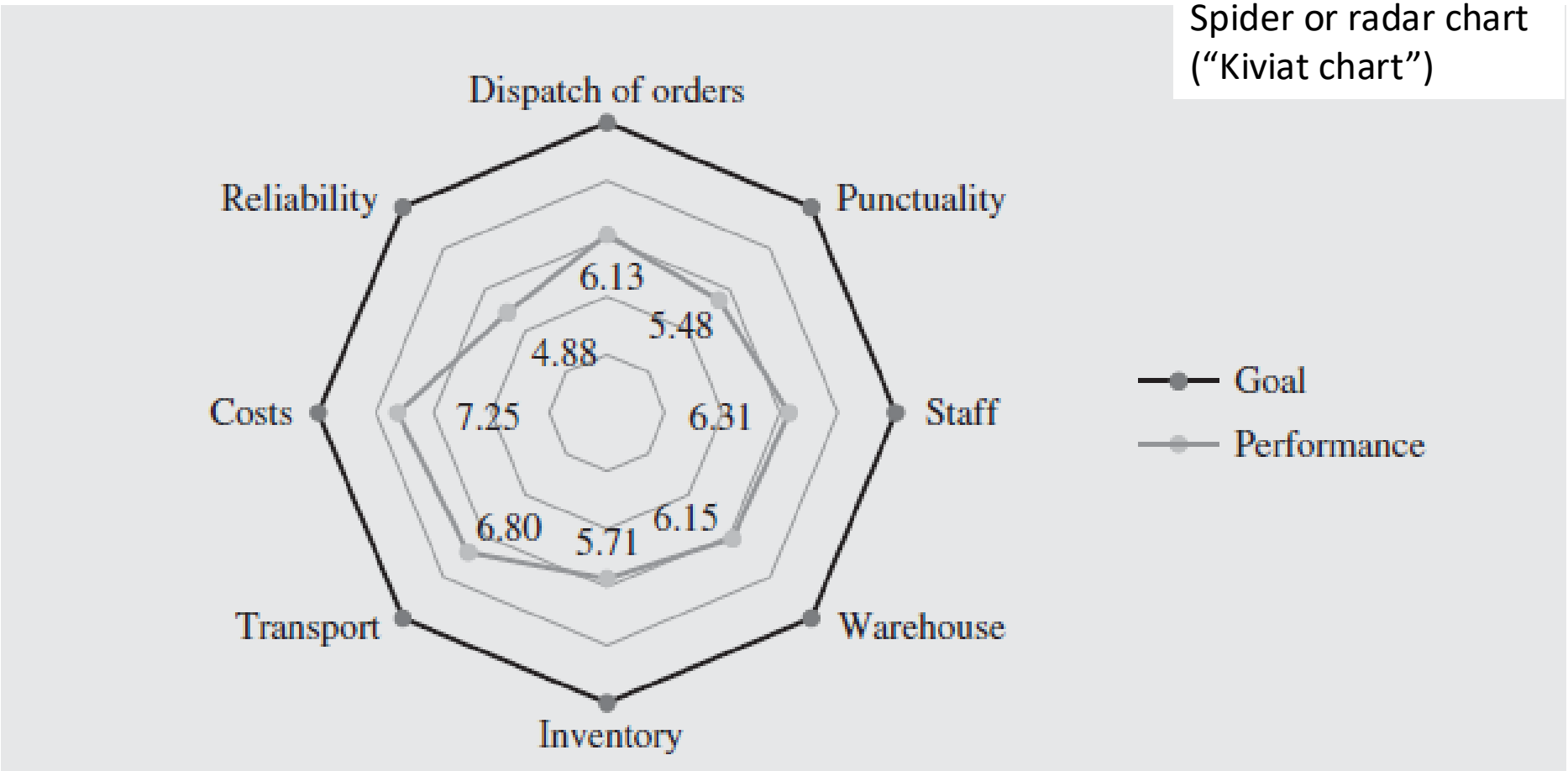
Final comments and closing

Fixed and variable costs

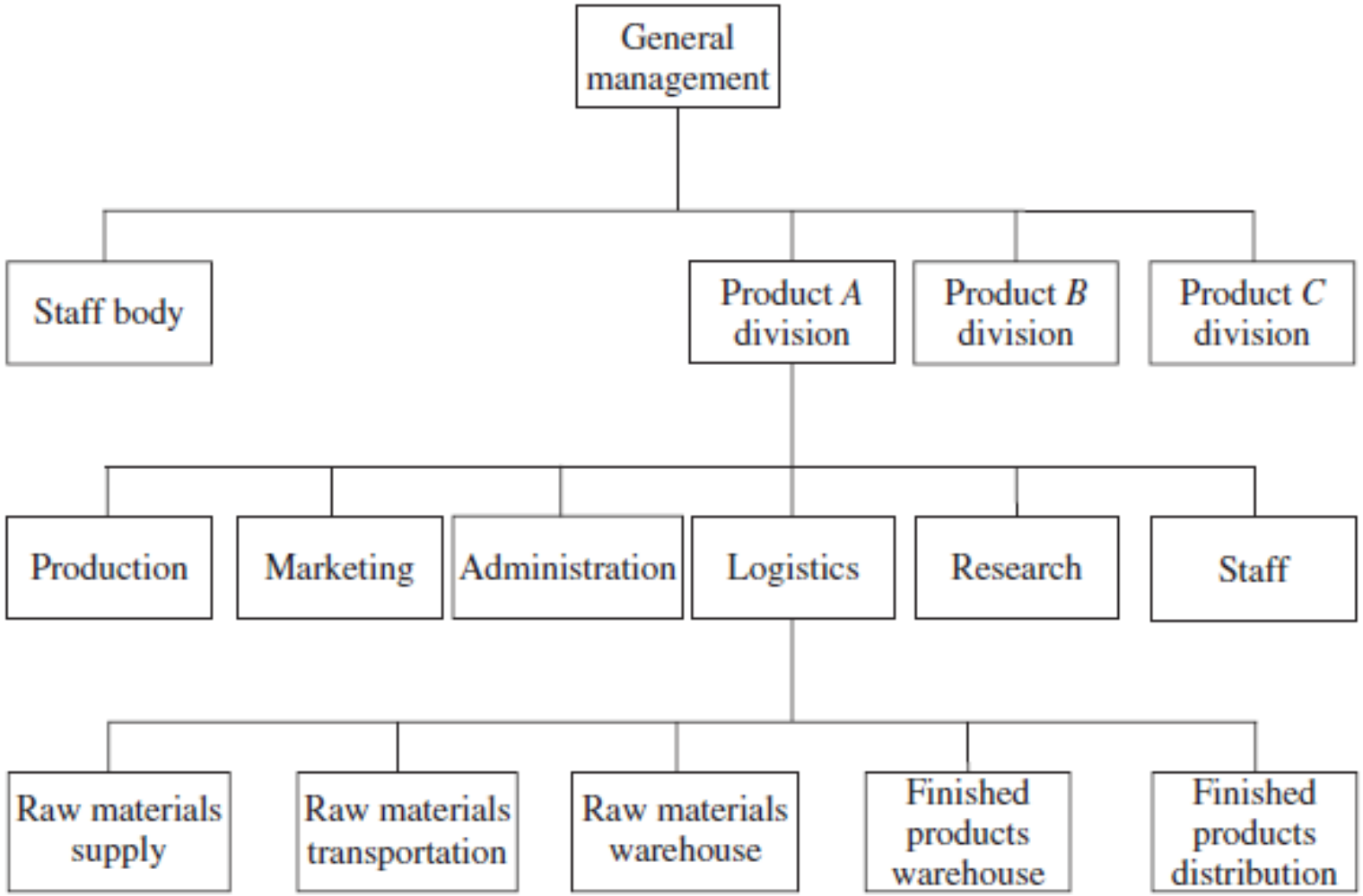
Main cost categories	Fixed costs	Variable costs
Storage costs	Administrative costs Running costs of storage centres	Insurance policies Financial burdens and opportunities costs Deterioration costs Obsolescence costs
Operational management costs	Administrative costs of issuing and computing orders	Loading and unloading goods costs Movement costs Stock control and management costs Packaging costs Deferment of takings Forfeits
Stockout costs		Lost sale Loss of customer Loss of image
Transport costs	Devaluation of means of transport Rental of means of transport	Insurance costs Variable transport costs
Plant and equipment costs	Rates of plant devaluation	Rental fees (variable according to volume)

Control panel “Kiviat” of a logistic control system over 1 month

Visually display multivariable data, i.e, several different metrics/characteristics on a single chart.



Organization chart



Discussion : adaptation to a moving environment

1. Labor and energy costs change over time; ethical issues and morality
2. Price of workers, of shortage, of relocation; ethical issues and morality
3. Business Process Improvement: “process” or “product” innovation
4. Customer Service Improvement
5. Macro economic forecasts (ΔGNP, risk analysis, moving barriers on trade)
6. Facing risk and in particular catastrophic risks
7. Retention, and just in time
8. Governmental Regulations
9. Environmental Issues
10. Technology Strategy & Implementation, and technological changes (e.g. AV)
11. Automation (production/transportation, and more!) ChatGPT, Bard,..→ jobs lost but also jobs created : who wins, who looses? (see Daron Acemoğlu, Joe Stiglitz,…)
12. Shift of preferences for telecommuting, teleshopping, impatience, green spaces,…