Knowing the Supply Chain – Why it is so Challenging

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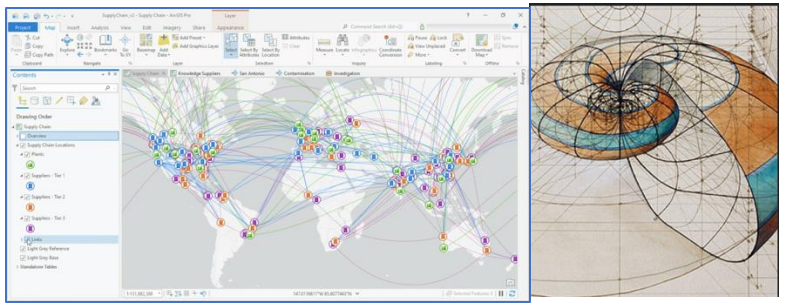
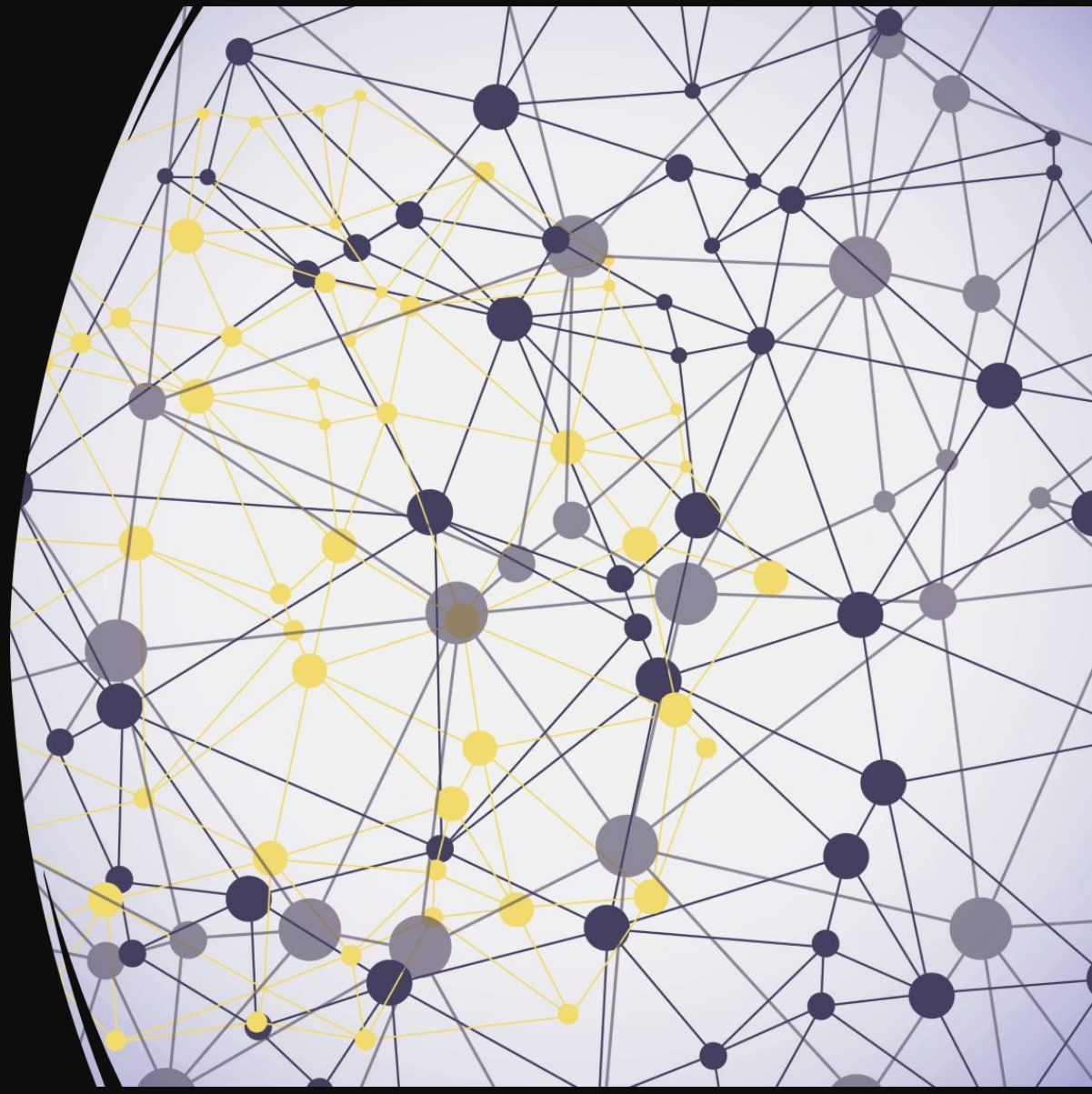


Agenda

1. Why and why now?
2. What to ‘map’?
3. Some examples
4. Why it is difficult
5. Why it is political/Political
6. Conclude



1. Why and why now?

Supply chains – up to 2016

- Make anything, anywhere
- Seamless, optimised, lean, just–in-time
- The earth is flat – operationally
- And then……

Since

FT Swamp Notes Global Economy + Add to myFT

It's the end of globalism as we know it (and I feel fine)

For the most part, its unravelling ought to be of deep concern. But we need a new social compact

Geopolitics entered the supply chain world

CLEAN CARS - HIDDEN TOLL

[Washington Post Aug. 4 2023]

Cobalt supply

Supply chains are more visible

Research agendas

Analysis

Collaboration

Digitalisation

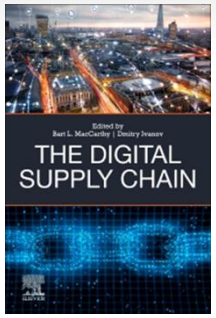
Typologies

Risk/ESG/CSR

Synthetic supply chains……

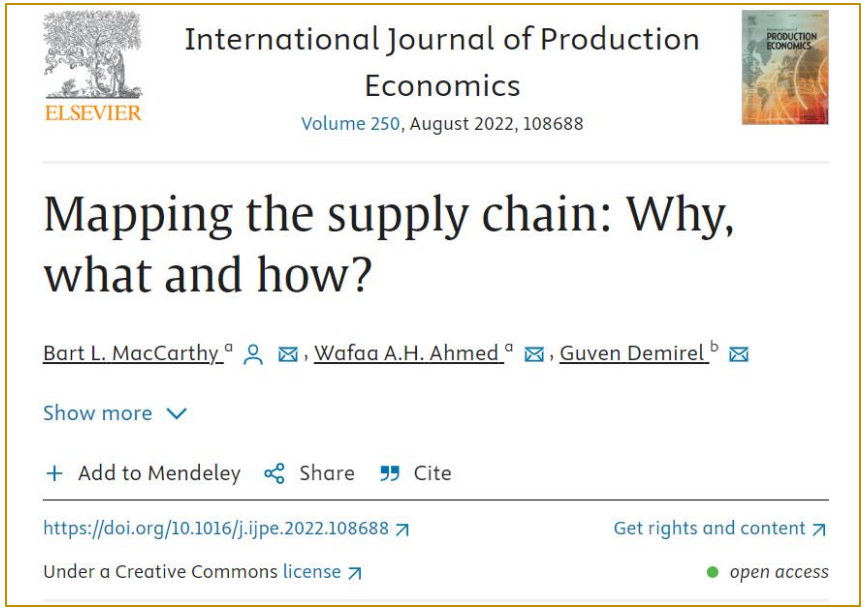
Performance improvement
Competitor analysis
M&A, sub-contract
Accreditation/certification
Tendering and bidding

Digital - Automate /Replace/Disintermediate
MacCarthy & Ivanov 2022



Legislation/regulation
Compliance/guarantees
Political – security of supply
Restrictions/regionalisation

2. What and how to map?



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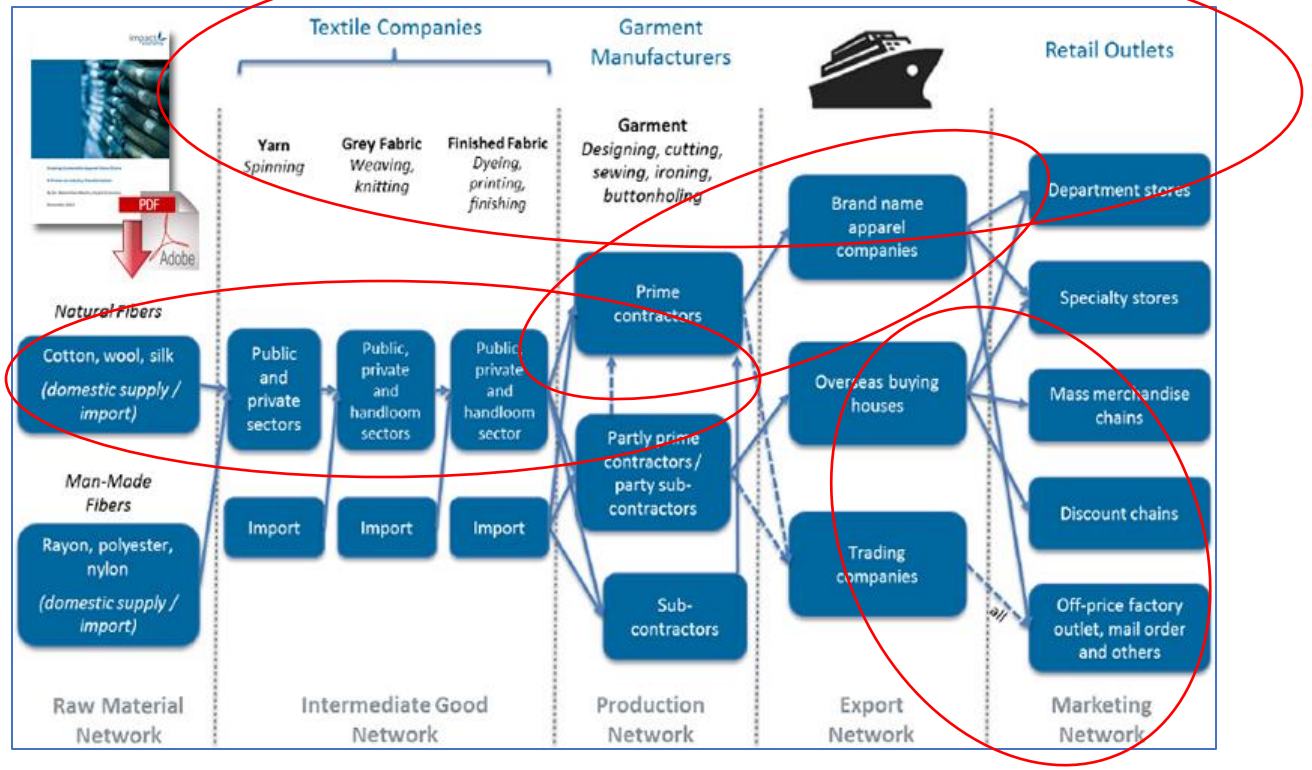
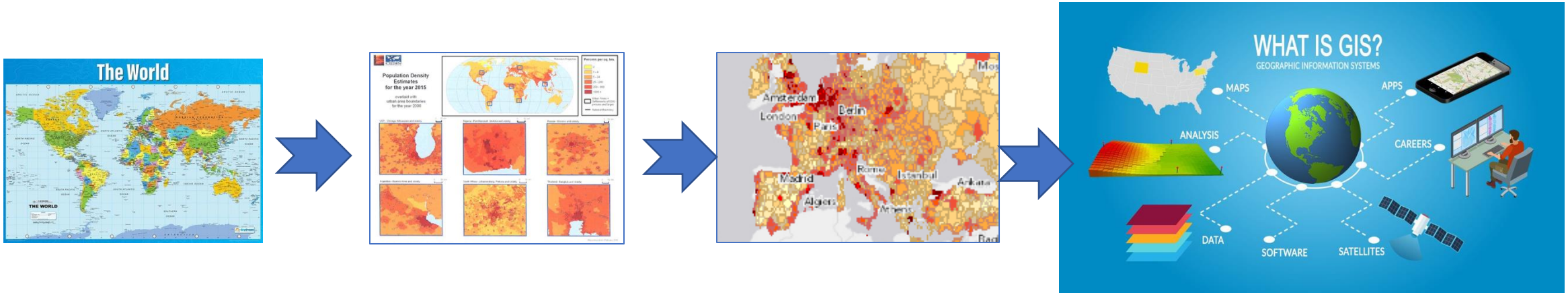
Specifying the level and scope

Textiles and clothing sector



‘unit of analysis’

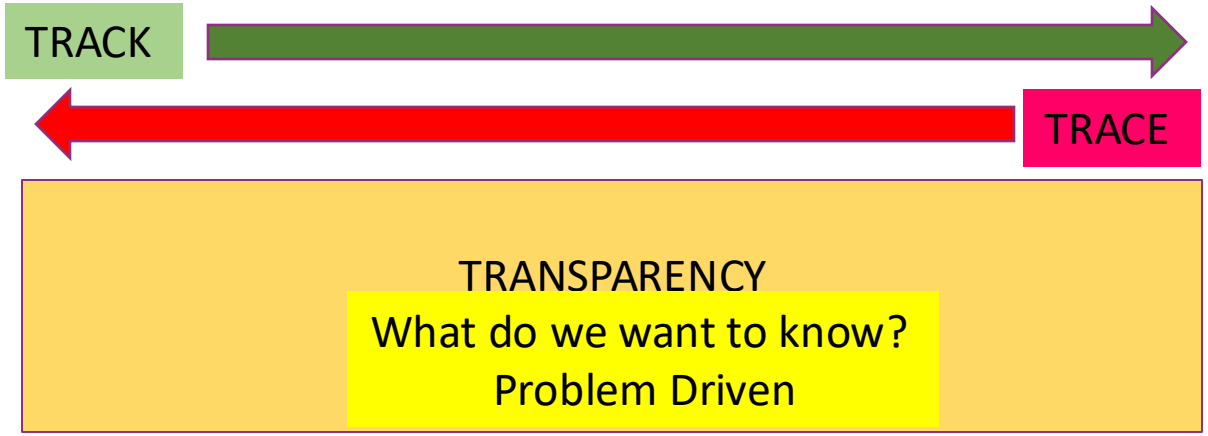
Specifying the level, scope and depth



Geographical Information Systems

- Maps are static – supply systems are dynamic
- Tacking /Tracing
- TRANSPARENCY

Ahmed & MacCarthy, 2023, IJPE



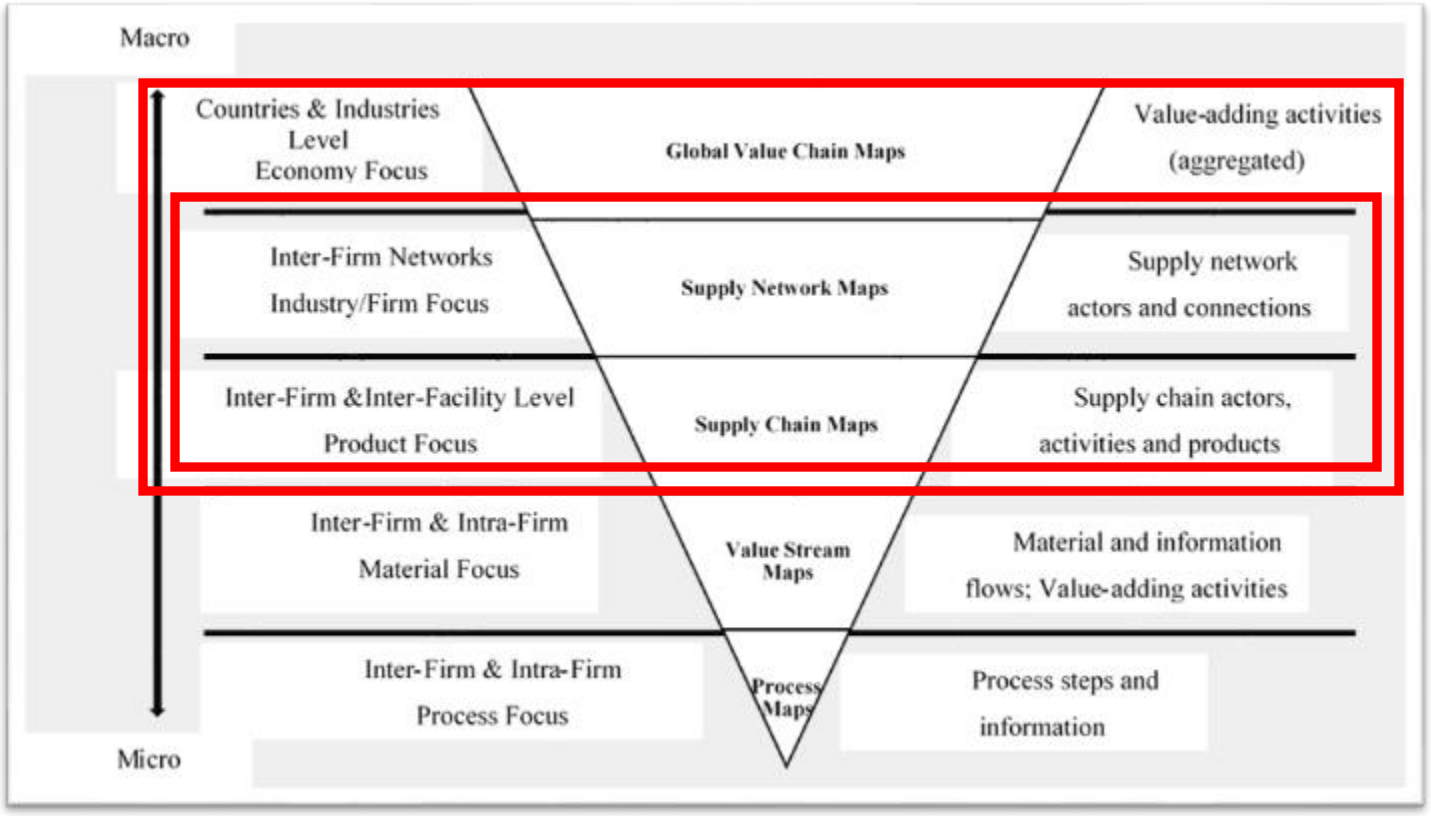
Hierarchy of supply systems

- Global Value Chain (GVC)
- Supply Network
- Supply Chain

……..

- Value Chain map
- Process map

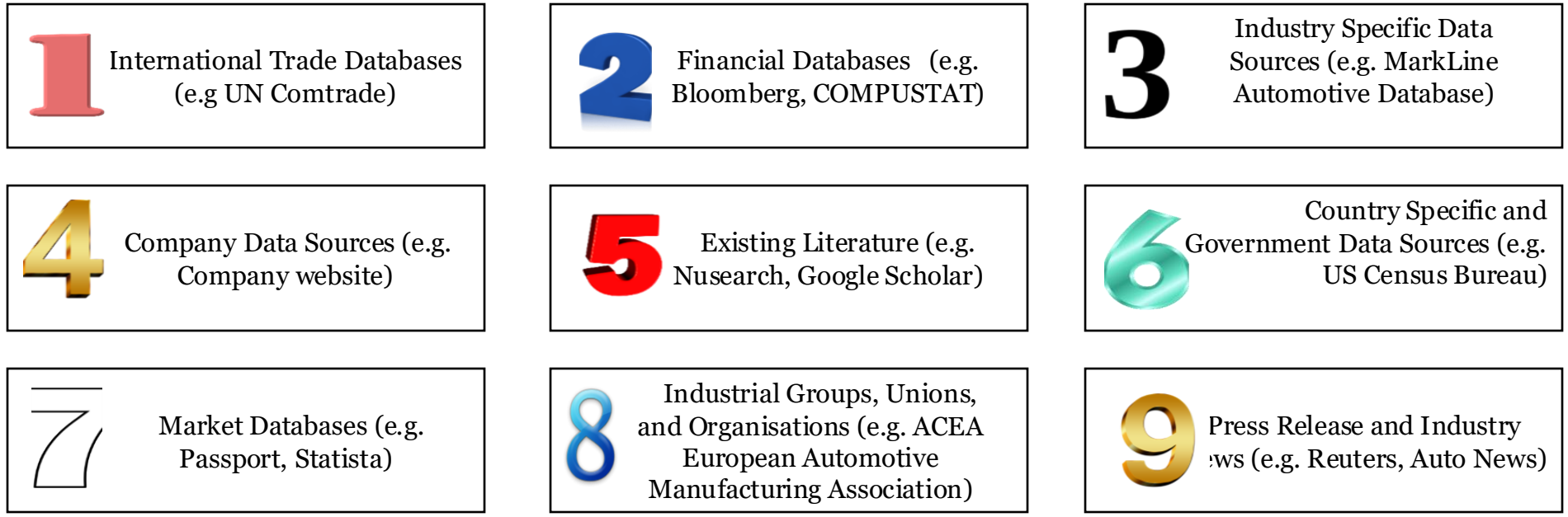
MacCarthy. Ahmed, & Demirel (2022)



MacCarthy, Ahmed & Demirel, G. (2022).

Primary/Secondary Data ?

- **Primary** – resource intensive even with access! + data sources needed
- **Secondary** - Financial databases, Industry specific sources – subscription, company sources, NGOs /Labour unions/Interested bodies
  - supply relationships extracted and curated from SEC and other filings/other information sources - 'relationship' information. Regulatory datasets, national accounts/VAT records. Banks/credit rating



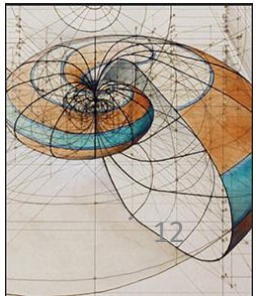
Secondary Data Sources

- **Bloomberg SPLC** (previously Connexiti)
  https://www.bloomberg.com/professional/dataset/global-supply-chain-data/
- **Compustat** - Supply Chain Suite databases
  https://www.spglobal.com/marketintelligence/en/solutions/panjiva-supply-chain-intelligence
  https://panjiva.com/
- **Factset Revere Supply Chain Relationships**
  https://www.factset.com/
- **Mergent Online Supply Chain**
  https://www.mergentonline.com/login.php
- **Industry specific**
  https://www.marklines.com/en/
- **Wider data sources**
  e.g. UN Comtrade
  https://comtradeplus.un.org/

Problems with data sets

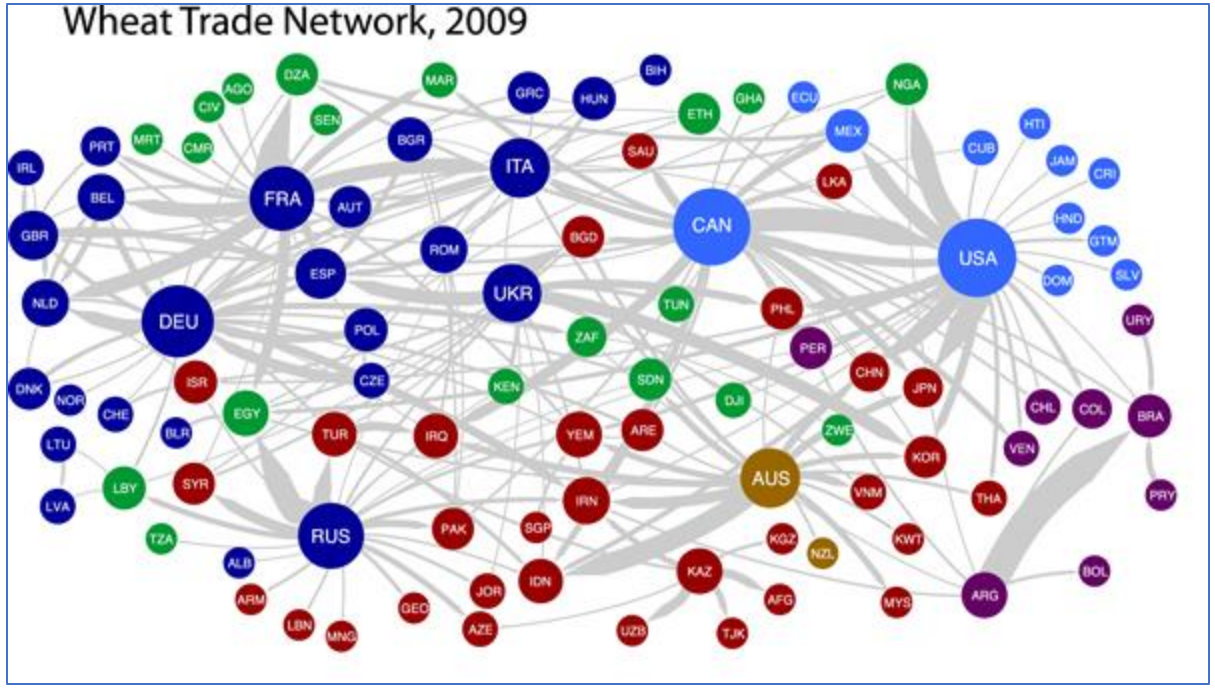
- Types of relationship - direct /indirect (software/service providers, finance/insurance, logistics)
- Lack of product info
- Boundaries
- Timeliness

Lots of **pre-and post-processing, inference** and **validation** needed!

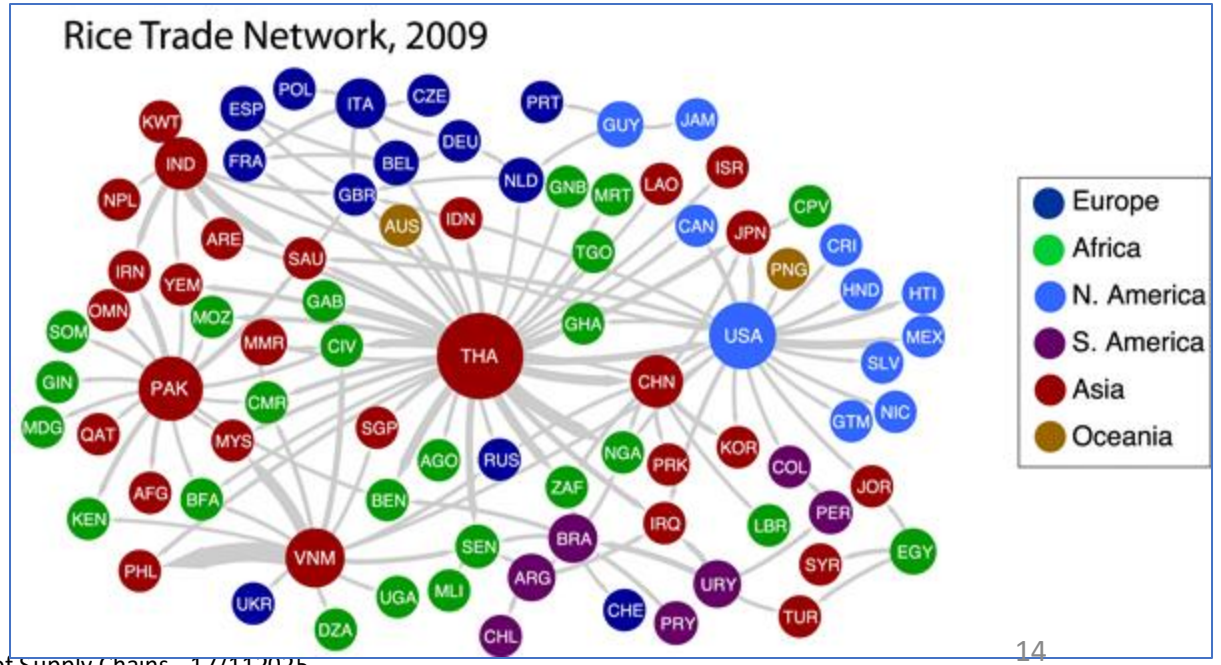


3. Some examples

Global commodity networks



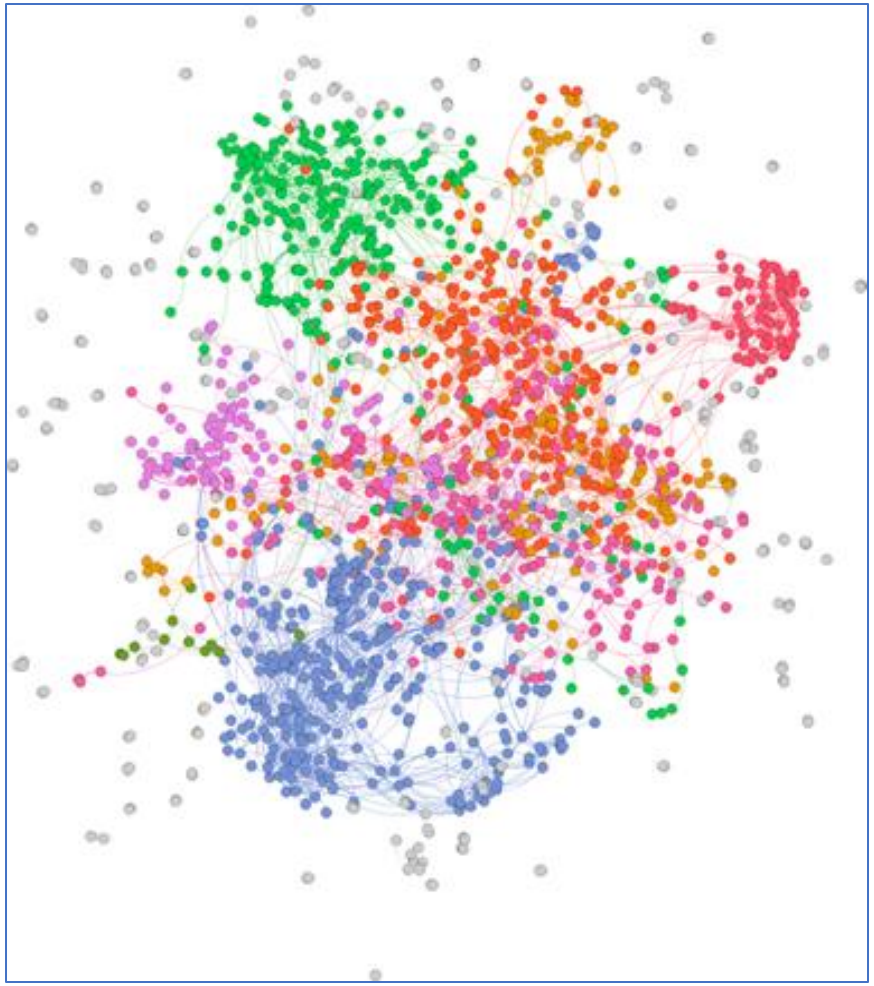
Puma, M. J., Bose, S., Chon, S. Y., & Cook, B. I. (2015). Assessing the evolving fragility of the global food system. *Environmental Research Letters*, *10*(2), 024007.



Extreme events - more connected, more fragile

Community detection

Clusters appear – community detection
Supply but the bigger network it inhabits – entwined/intertwined



Node

From: Demirel (2022)

- Which firms are most important/critical in the supply network? (Node centrality)
- How redundant are the connections of a focal firm? How likely are the suppliers and customers of a firm to interact directly with each other? (Clustering)

Links

- Which connections of a firm are more important? (Link weight, Hub-authority scores)
- Network - How much do firms differ from each other with respect to their number of connections? (Degree distribution)

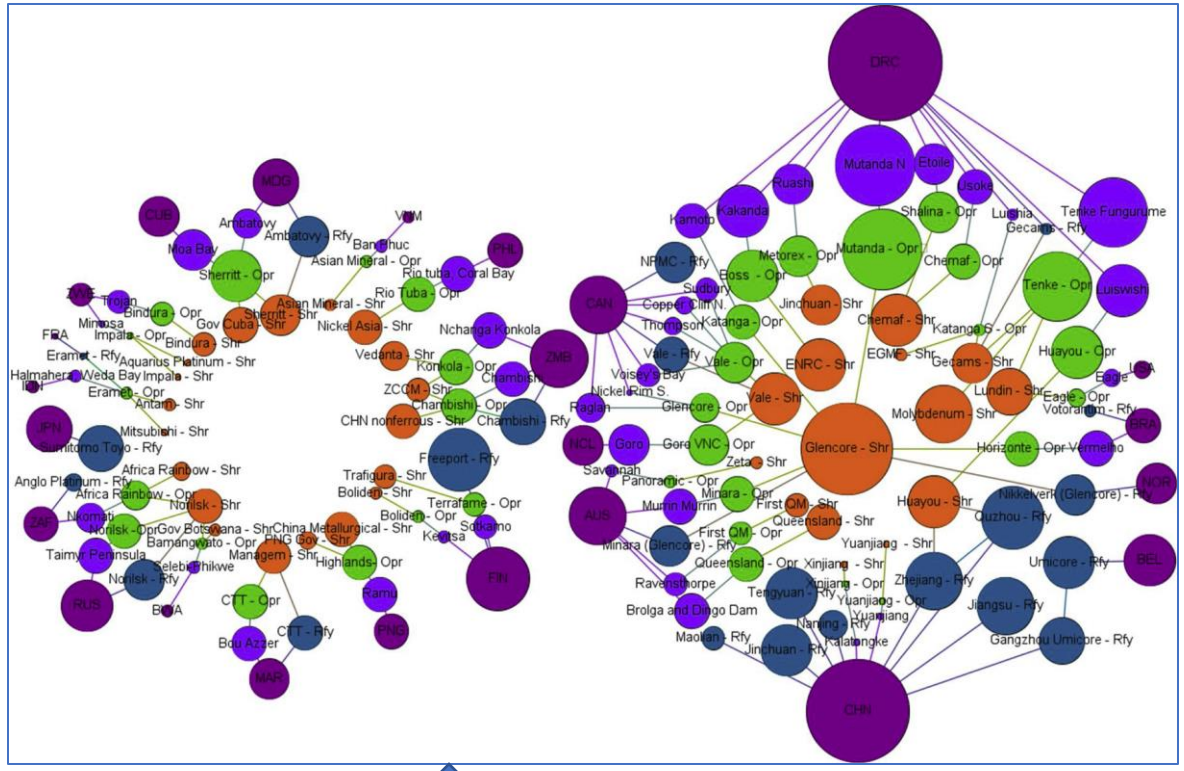
Network

- How efficiently can information and materials be transmitted on the supply network? How quickly can you reach other nodes on a network? (Geodesic distance)
- Do firms self-organize into closely knit groups with shared interests and/or latent characteristics? (Community detection)

FIGURE 23.3 Network visualization by community membership for the industry network of US-based publicly listed companies. The buyer–supplier relationships between all firms in year 2019 are based on the Compustat Supply Chain Suite dataset. The graph visualization is made in Gephi with the force atlas layout,. The network is partitioned into communities by the Louvain algorithm. Different colors highlight distinct industrial communities, which include firms along supply chains as well as the same industries.

Network generation methods

Cobalt industry


DRC
Mutanda N
Etoile
Ruashi
Kakanda
Kamoto
Usoka
Shalina - Opr
Luishia
Tenke Fungurume
Gecamines - Rfy
Mutanda - Opr
Metorex - Opr
NRMC - Rfy
Boss - Opr
Chemaf - Opr
Tenke - Opr
Luiswishi
Sudbury
Jinchuan - Shr
Chemaf - Shr
Katanga S - Opr
Huayou - Opr
Eagle
Gecamins - Shr
Lundin - Shr
Eagle - Opr
Votorantim - Rfy
Horizonte - Opr Vermelho
Nikkelverk (Glencore) - Rfy
Quzhou - Rfy
Umicore - Rfy
Zhejiang - Rfy
Jiangsu - Rfy
Gangzhou Umicore - Rfy
Glencore - Shr
Molybdenum - Shr
ENRC - Shr
EGMC - Shr
Vale - Shr
Vale - Opr
Vale - Rfy
Katanga - Opr
Thompson
Copper Cliff N
Nickel Rim S.
Raglan
Glencore - Opr
Goro - Opr
VNC - Opr
Zeta - Shr
Panoramic - Opr
Minara - Opr
Murrin Murrin
First QM - Shr
First QM - Opr
Queensland - Shr
Yuanjiang - Shr
Xinjiang - Shr
Xinjiang - Opr
Yuanjiang - Opr
Tengyuan - Rfy
Yuanjiang
Nanning - Rfy
Kalatongke
Jinchuan - Rfy
Maolian - Rfy
Ravensthorpe
Brolga and Dingo Dam
Minara (Glencore) - Rfy
Queensland - Opr
Savannah
Nchanga Konkola
Konkola - Opr
Chambishi
Chambishi - Opr
Chambishi - Rfy
ZCCM - Shr
CHN nonferrous - Shr
Vedanta - Shr
Nickel Asia - Shr
Asian Mineral - Shr
Rio Tuba - Opr
Rio tuba - Coral Bay
Asian Mineral - Opr
Bangchuc
VNM
PHI
Ambatovy
Ambatovy - Rfy
Moa Bay
Sherritt - Opr
Sherritt - Shr
Gov Cuba - Shr
Bindura - Opr
Bindura - Shr
Mimosa
Impala - Opr
Eramet - Rfy
Aquarius Platinum - Shr
Weda Bay Impala - Shr
Eramet - Opr
Antam - Shr
Mitsubishi - Shr
Sumitomo Toho - Rfy
Africa Rainbow - Shr
Anglo Platinum - Rfy
Africa Rainbow - Opr
Norilsk - Shr
Norilsk - Opr
Gov Botswana - Shr
China Metallurgical - Shr
Barrangonato - Opr
RNG Gov - Shr
Taimyr Peninsula
Norilsk - Rfy
Selebi-Phikwe
Managem - Shr
Highlands - Opr
Terrafame - Opr
Boliden - Opr
Boliden - Shr
Trafigura - Shr
Freeport - Rfy
Sotkamo
Kevitsa
Harjavalta
Pori
Boliden
Aurubis
Umicore - Rfy
Hoboken
Olen
Lommel
Umicore - Opr
Umicore - Shr
Umicore - Opr
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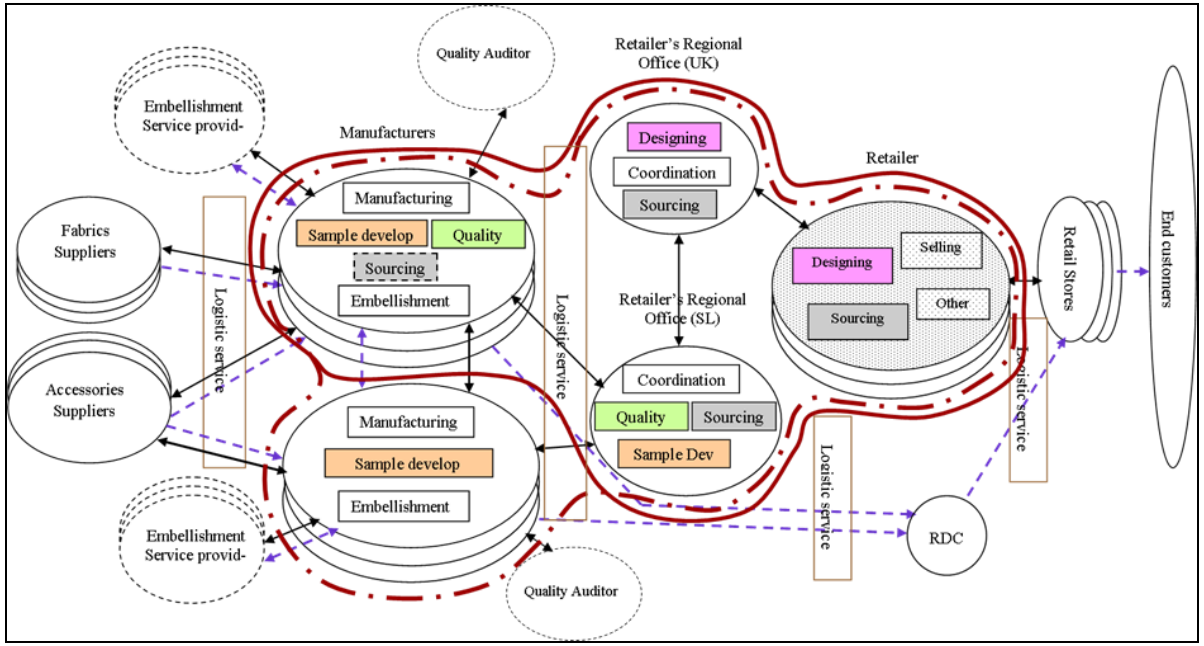
Umicore - Rfy

Personal journey



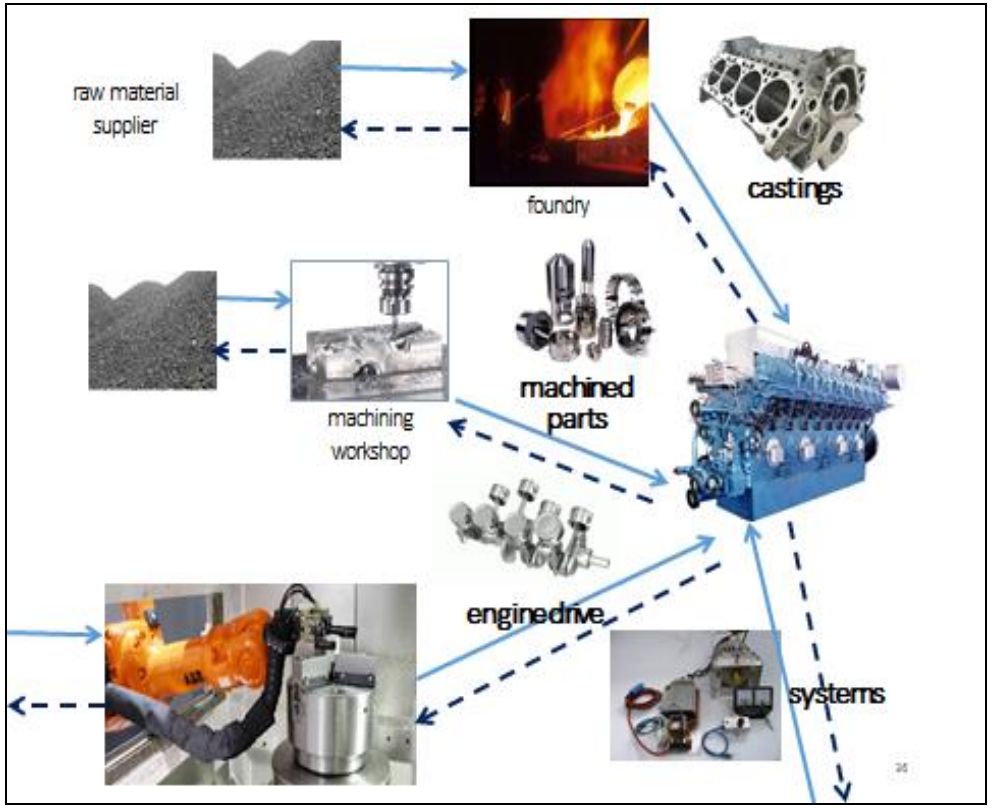
International clothing supply networks

MacCarthy & Jayarathne, 2013, IJOPM

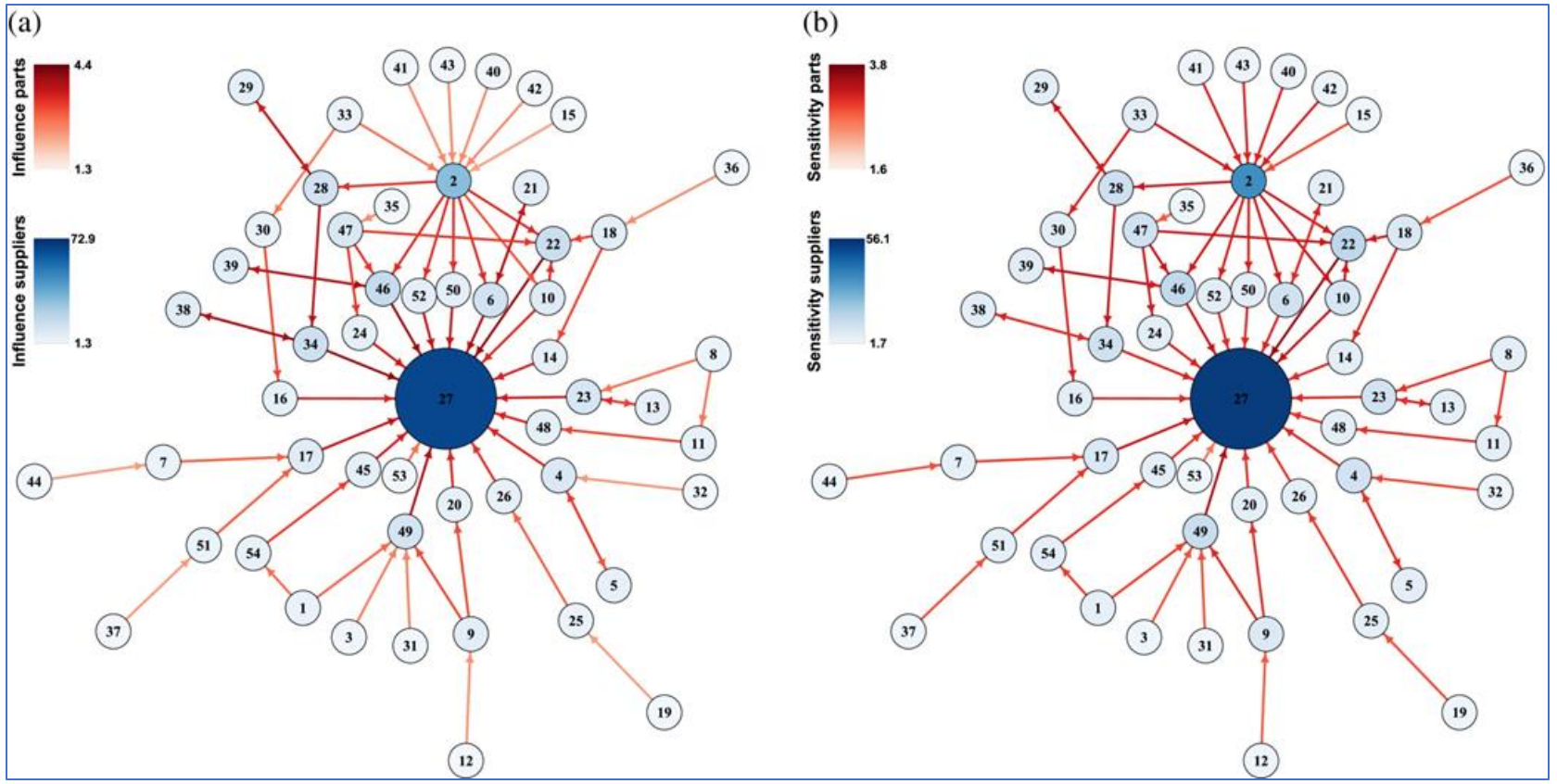
MacCarthy et al. 2016 – Supply Chain Evolution , IJOPM

Marine engine supply network

Demirel et al., 2019, JOM



Inbound for an OEM



Influence and sensitivity of parts and suppliers in the inbound supply network of an engineered product. (a) Influence of supplier (blue) and parts (red) on instability. (b) Sensitivity of suppliers and parts toward perturbations.

Demirel, G., MacCarthy, B. L., Ritterskamp, D., Champneys, A. R., & Gross, T. (2019). Identifying dynamical instabilities in supply networks using generalized modeling. Journal of Operations Management, 65(2), 136-159.

Automotive OEM Global Leather Supply Chain Map – The Traceability Challenge

Farms
Tier 10,9, 8, 7, 6, 5

Leather Sources

Leather Production
Tier 5,4, 3

Cut and Trim

Interior Assemblers
Tier 1

Farms Argentina → Abattoirs Argentina → Sub Tannery Argentina

Farms Europe → Abattoirs Europe

Farms Europe /North America → Abattoirs Europe /North America → Sub Tannery

Farms Brazil → Abattoirs Brazil → Sup-tanneries Brazil

Farms Brazil → Abattoirs Brazil → Sub Tannery (JBS) Brazil

Farms World Wide → Abattoirs → Agents

Directed Supply Chain – OEM nominate leather producers

- Leather Supplier 1 UK
- Leather Supplier 2 Italy
- Leather Supplier 3 Germany/ Hungary
- Leather suppliers China/ Solvakia

Cutting/ Sewing/ Wrapping

Seat Manufacturer & Head Rest

Seat Manufacturer

Head Liner Supply Chain

Arm Rest Supply Chain

Door Casing Supply Chain

IP & C Supply Chain

OEM

Information Flow

Material Flow

Global Automotive Leather Supply – Argentinian Case

1. Limited / variable regulation and trusted data upstream eg no cattle passport in South America
2. Could adopt '**Trust Points**' from Tannery (ie aggregators of upstream data).... But relies on Tannery verifying and maintaining upstream provenance
3. Direction of travel towards improved traceability driven by export driven pressure
4. Would require specific technologies and Trust Point focus on key risks eg Deforestation / Animal Welfare

Risks
- Gran Chaco Deforestation
- Animal welfare

Leather Sources

Cutting / Sewing / Wrapping

Interior Assemblers

Other Global Leather Supply Chain

Other Leather Suppliers

Trust Point

Cutting/Sewing/Wrapping Facilities

Seat Manufacturer

Head Liner Supply Chain

Arm Rest Supply Chain

Door Casing Supply Chain

IP & C Supply Chain

Exec Bolster
Semi-Aniline

Germany
Seating
Semi-Aniline

Morocco Facility(90%)
Seating
Semi-Aniline / Tauruas

Outsourced Wrapping Facility - UK

Serbia
Headrests
Semi-Aniline

Poland
Headrests
Semi-Aniline

Seat Manufacturer & Head Rest

OEM

Farms
Europe

Abattiors
Europe

Farms
Argentina

Abattiors
Argentina

Sub Tannery
Las Toscas -Santa Fe Chrome (Automotive) - Argentina
Crust Leather

Leather Supplier 1
UK

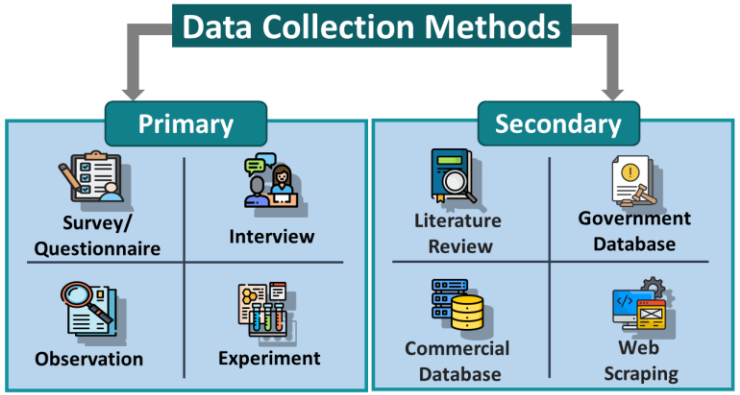
Trust Point

Ahmed & MacCarthy, 2023, IJPE

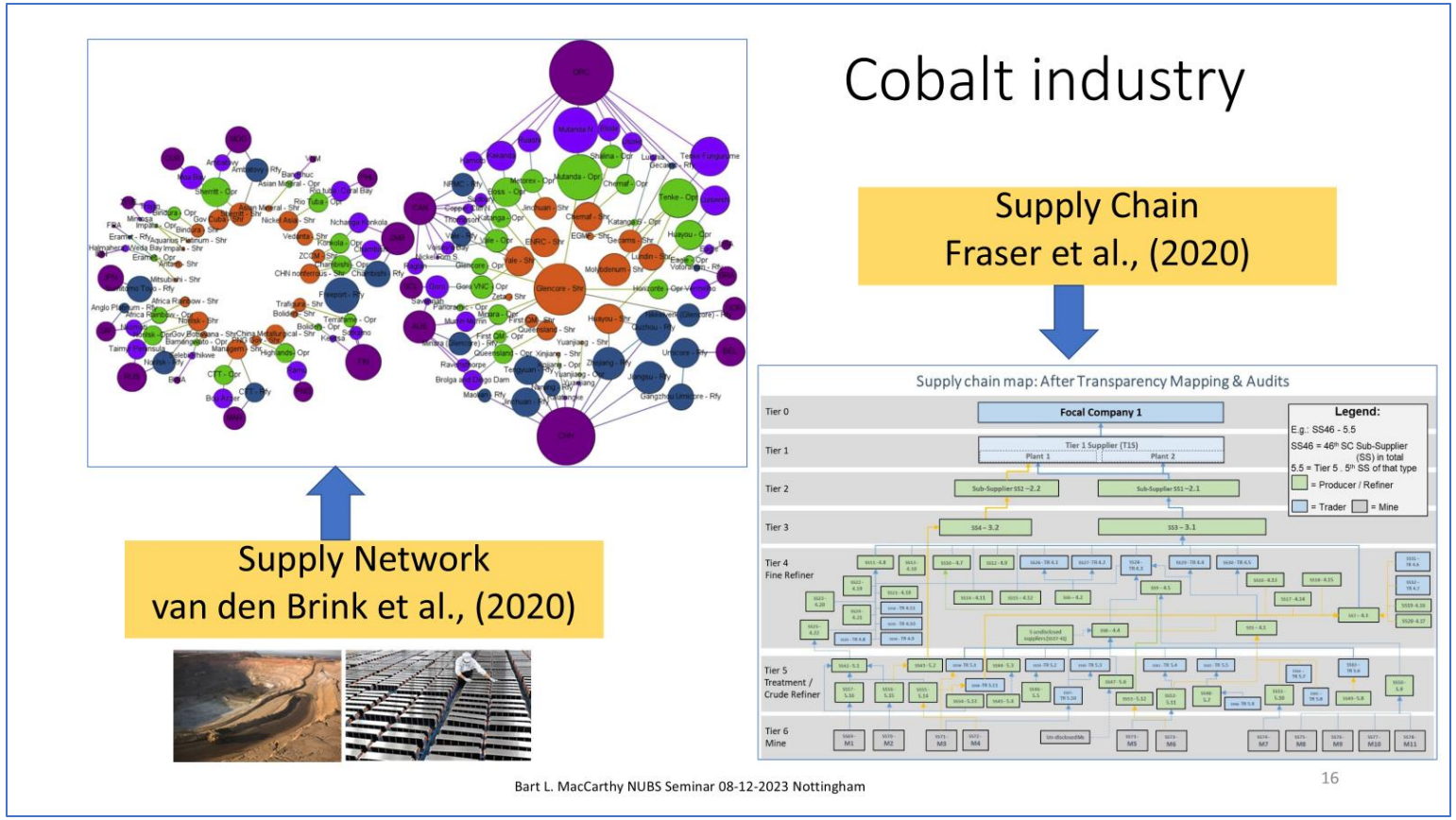
Why it is difficult to ‘know’ the supply chain

- Limited requirements to disclose
- Nobody's responsibility to capture end-to-end supply chains/networks
- Primary data
  - Data collection is resource intensive and faces problems
  - Who do you ask?
  - Do they know?
  - Are they willing to disclose?
  - Commercial sensitivities /IPR

- Secondary data
  - Inferring from fragmented /Inconsistent/missing data
  - Vast extent of many global supply systems
  - Dynamic, spanning multiple tiers and jurisdictions.
  - Some sectors are more reported than others
  - Commercial sensitivities limit publicly accessible data
  - Depends on what you want to know

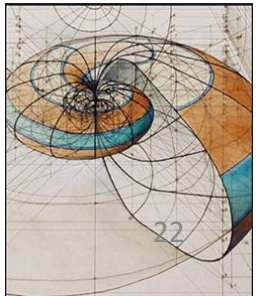


Why it is political and Political



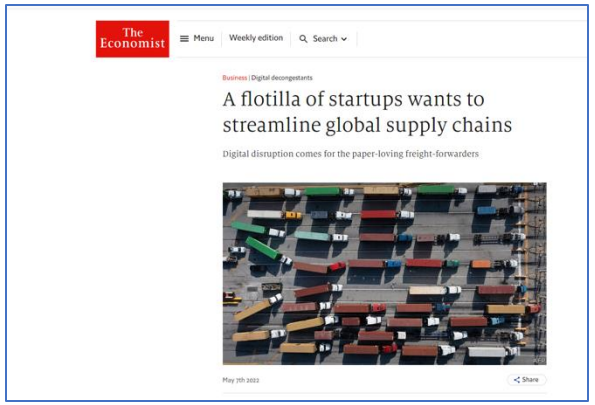
The configuration of company networks and supply chain maps raise many political questions

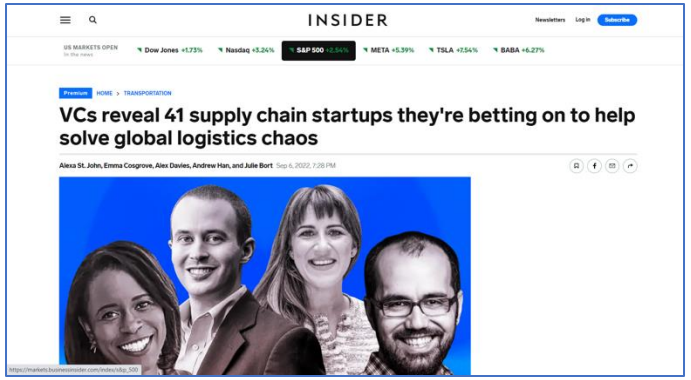
- Ownership
- Authority
- Responsibility
- Control
- Jurisdiction
- Security
- Reputation

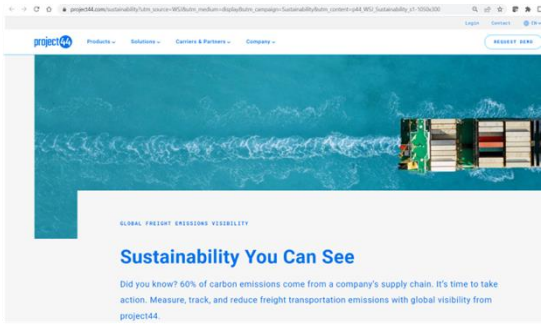


Conclude

- Effective due diligence, sustainability reporting, and resilience planning all depend on knowing who is connected to whom, how, and where.
- We need more ‘maps’ but they are challenging to construct (and may not be possible)
- Many start ups offering ‘mapping’ solutions…watch this space





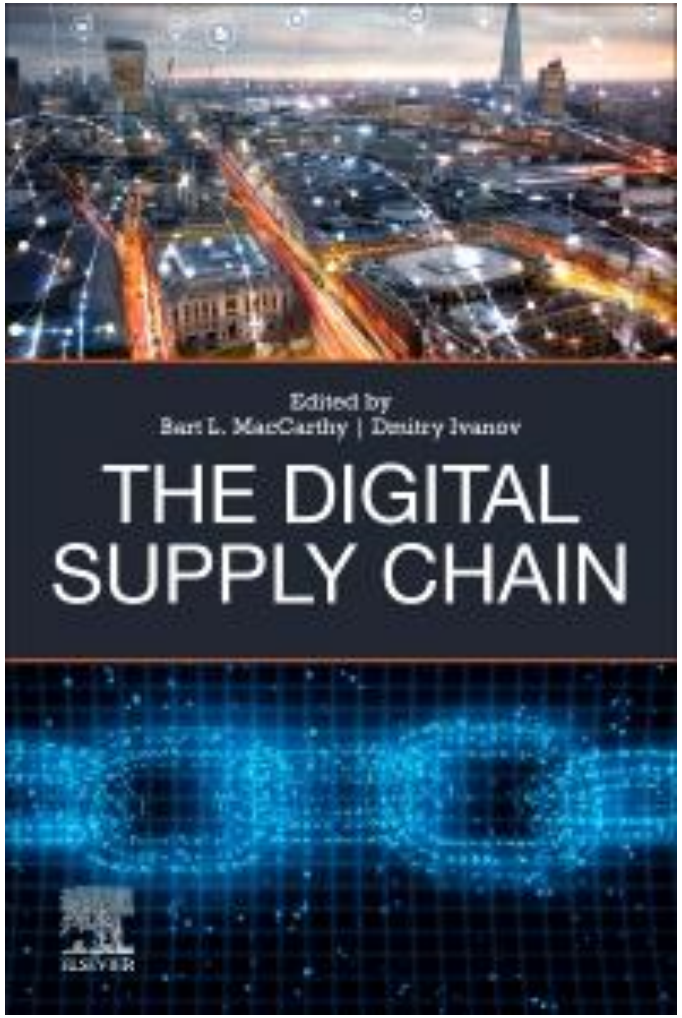


FRDM

Makersite

The Digital Supply Chain

The Digital Supply Chain
Bart MacCarthy, Dmitry Ivanov
Paperback ISBN: 9780323916141 – 20th June 2022



Part 1. Introduction

1. The Digital Supply Chain – Emergence, Concepts, Definitions, and Technologies
   Bart MacCarthy and Dmitry Ivanov

Part 2. Digital Building Blocks and Enabling Technologies

2. Digital Manufacturing - The Evolution of Traditional Manufacturing Toward an Automated and Interoperable Smart Manufacturing Ecosystem
   Dimitris Mourtzis, John Angelopoulos and Nikos Panopoulos
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   Sven Winkelhaus and Eric H. Grosse
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QUESTIONS, COMMENTS, QUERIES