



**University of Natural
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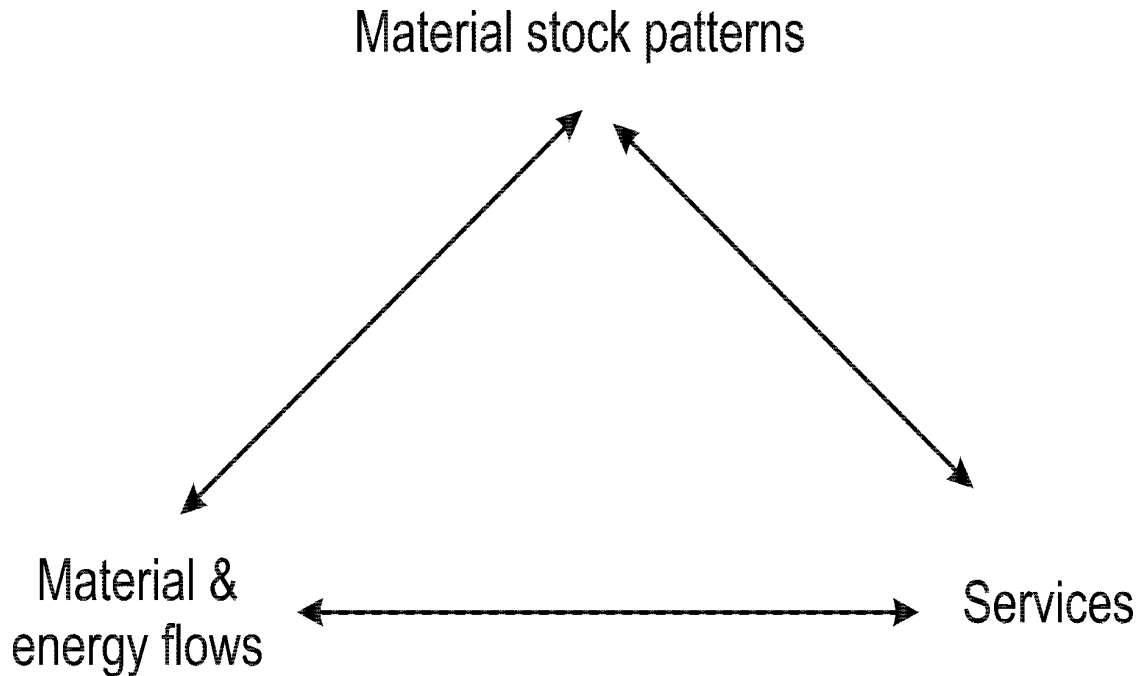
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Assembling the empirical basis for the stock-flow-service nexus: national level material stocks by major end-uses and their distribution in space

Barbara Plank, Jan Streeck, Doris Virág

Presentation at the 1st online-intermezzo of the Young Researcher Seminar on Sustainable Material Cycles

The MatStocks projekt - reveiling the stock-flow-service nexus



Key characteristics of stocks

- **Functional types** e.g. buildings, infrastructures, machinery
- **Spatial patterns** e.g. urban form
- **Qualities** e.g. thermal quality of buildings

Material and energy flows are key for understanding resource constraints & ecological impacts, e.g. climate change

Service indicators beyond GDP establish links between resource use, well-being and satisfaction of human needs

Stock and flow modelling approaches



Inflow-driven / top-down

National-level material consumption over time & dynamic stock-modelling with lifetime distributions

- Stock-flow database for 180 countries 1900-2016 for 16 stock-building materials
 - Uncertainty assessment
 - Distinction of end-uses

Stock-driven / bottom-up

Functional units (e.g. buildings, road-km, power plants) & material intensities

- Spatially-explicit mapping of cities and countries
- Case studies on
 - Global electricity provisioning system
 - Road infrastructure system
 - Countries and cities

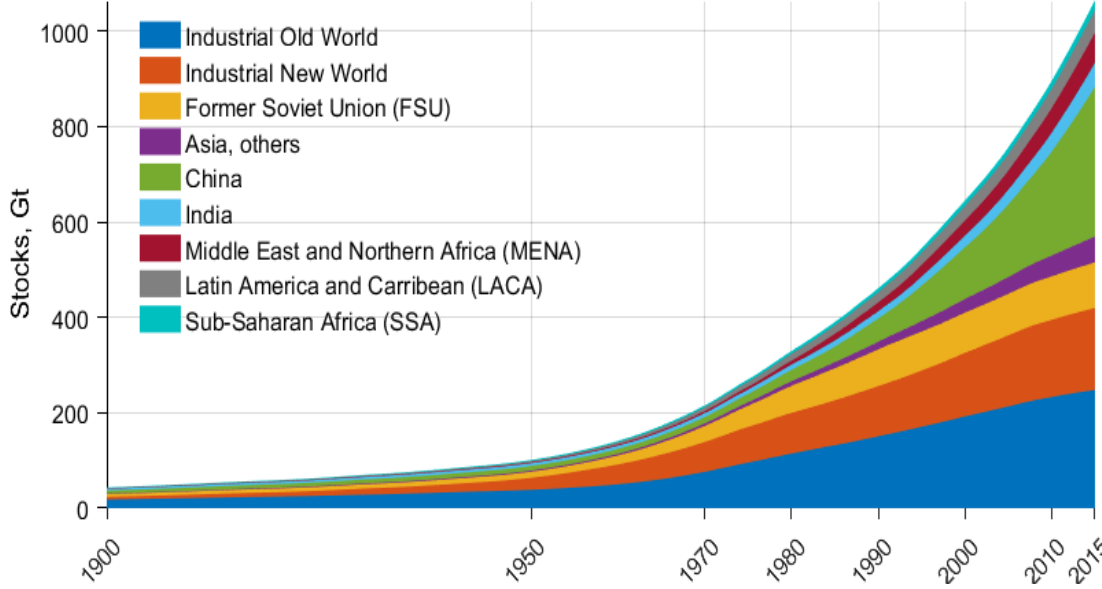
Barbara Plank

Country-level material flows and stocks database

Results for world regions

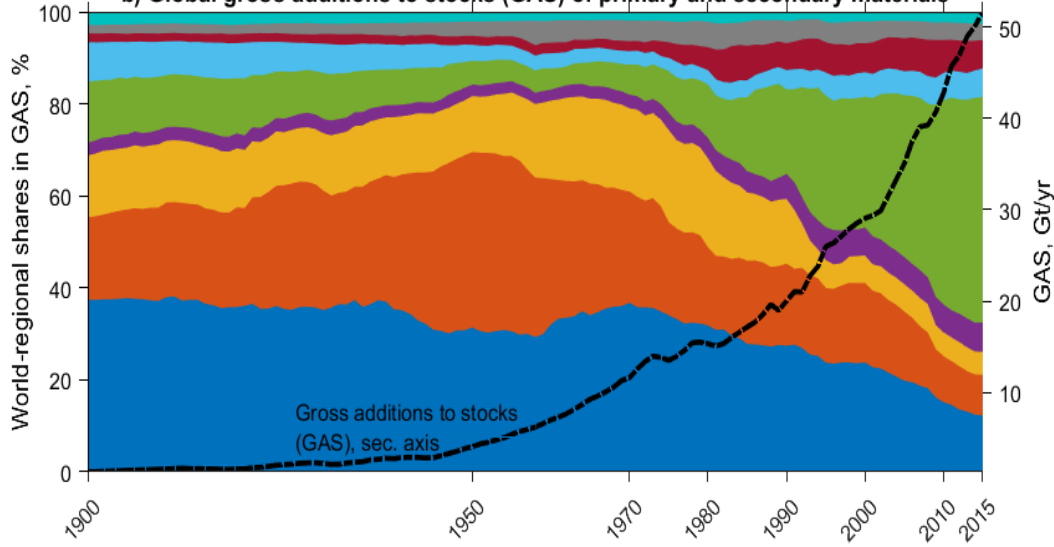


a) Material stocks in nine world-regions, from 1900 to 2015



- Hardly any saturation, also in industrialized regions
- China drives global stock-flow dynamics since the 1990

b) Global gross additions to stocks (GAS) of primary and secondary materials



- Other regions accelerated their stock growth
- Inequalities in per-capita stocks are large

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Conclusions & further steps

- Ageing stocks drive growing end-of-life, maintenance and replacement flows
- Optimal replacement and stock management strategies required to improve stock-flow-service efficiency

We need a better understanding of the connection to material service provision!

- Country-level comparisons to well-being indicators
 - Further distinction of end-uses of material stocks
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Jan Streeck

Options for deriving material end-uses for inflow-driven MFA

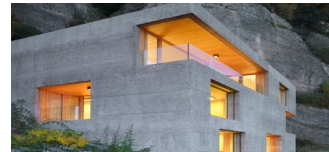
Towards material end-uses

- Connecting material use to **service-units** (e.g. floor area)...
- ...requires info on material **use in products** (or **end-uses**)
- **Bottom-up** MFA inherently distinguishes end-uses
- **Top-down** material use statistics not differentiated by end-use



Cement in all applications

end-use 1

Cement in buildings

end-use 2




Cement in transport infrastructure

Options for end-use splits for inflow-driven models

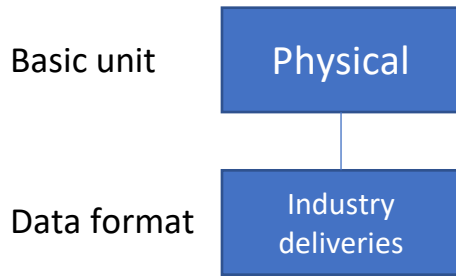


Table S15: Sector split for the US, 2004. (American Iron and Steel Institute 1941-2005)

Market	Sector	tonnes/yr, 2004
Construction	Construction	23,809,700
Automotive	Transport	13,857,470
Rail Transportation	Transport	1,184,925
Shipbuilding	Transport	146,158
Aircraft	Transport	30,194
Oil and Gas Industry	Machinery	2,487,056
Mining Quarrying	Machinery	243,276
Agricultural	Machinery	417,900
Machinery	Machinery	1,853,435
Electrical Equipment	Products	2,026,067
Appliances	Products	919,685
Other Domestic and Commercial Equip.	Products	790,317
Containers, Shipping Materials	Products	2,592,186
Ordnance and other military	Machinery	70,787
All		50,429,156

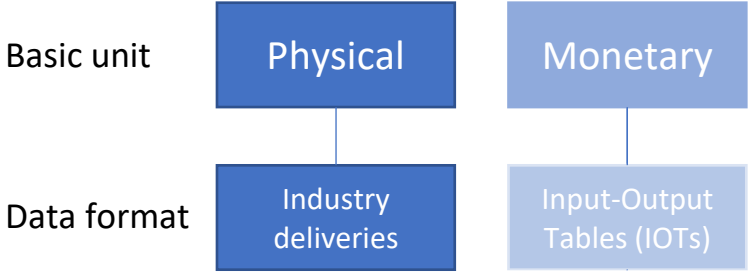
Sector split	
Sector	
Transport	0.3
Machinery	0.1
Construction	0.47
Products	0.13

- Information **scarce**, lacking:
 - time resolution
 - country resolution
 - material resolution
 - Often not 100% of apparent consumption reported

The ratio of the total steel shipped to domestic crude steel production in 2004 is 50%.

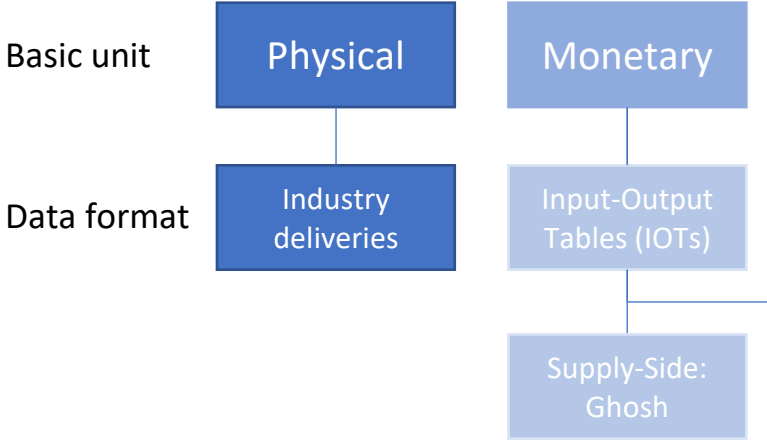
from Pauliuk et al. 2013

Options for end-use splits for inflow-driven models



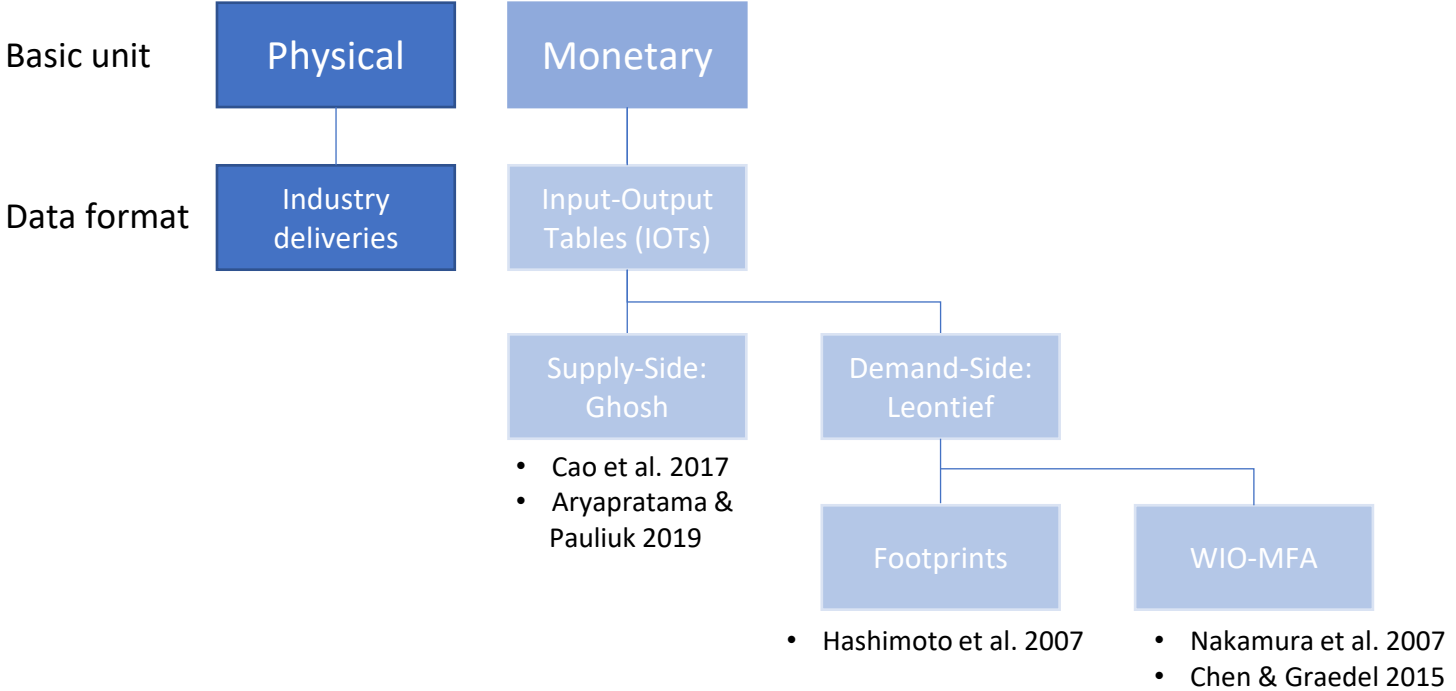
- Attractive for economy-wide MFA as IOTs reflect macroeconomics

Options for end-use splits for inflow-driven models



- Cao et al. 2017
- Aryapratama & Pauliuk 2019

Options for end-use splits for inflow-driven models



Comparison of IOT-derived end-use splits...

...with physical end-use splits over longer time periods is lacking

- We want to compare these two data sources for:
 - **USA** official IOTs 1963-2012
 - 500 products → very detailed end-use splits possible in theory
 - **Global** Exiobase IOTs – 1995-2011
 - 200 products
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Preliminary conclusions end-use splits

- IOT-derived results for some materials fit well

to physical end-use data

- Some remaining issues

- Detail of end-use splits?

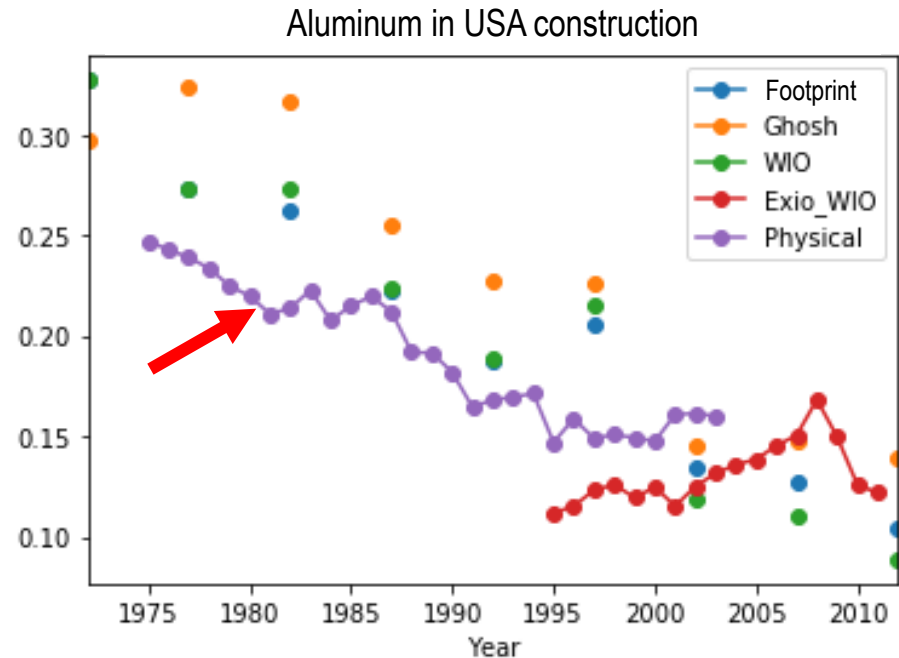
- ...

- Next steps

- Refine approaches

- Apply to USA economy-wide material use to distinguish stock types

- Check global applicability with Exiobase



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Doris Virág

Stock-driven modelling

(1) High-Resolution Maps of Material Stocks in Buildings and Infrastructures in Austria and Germany

High-resolution maps of 23 stock types and 13 materials

→ Earth-observation & OSM data, material intensity factors



Buildings

- Lightweight
- Single-family
- Multi-family
- Multi-family >30m
- Commercial/industrial

Roads

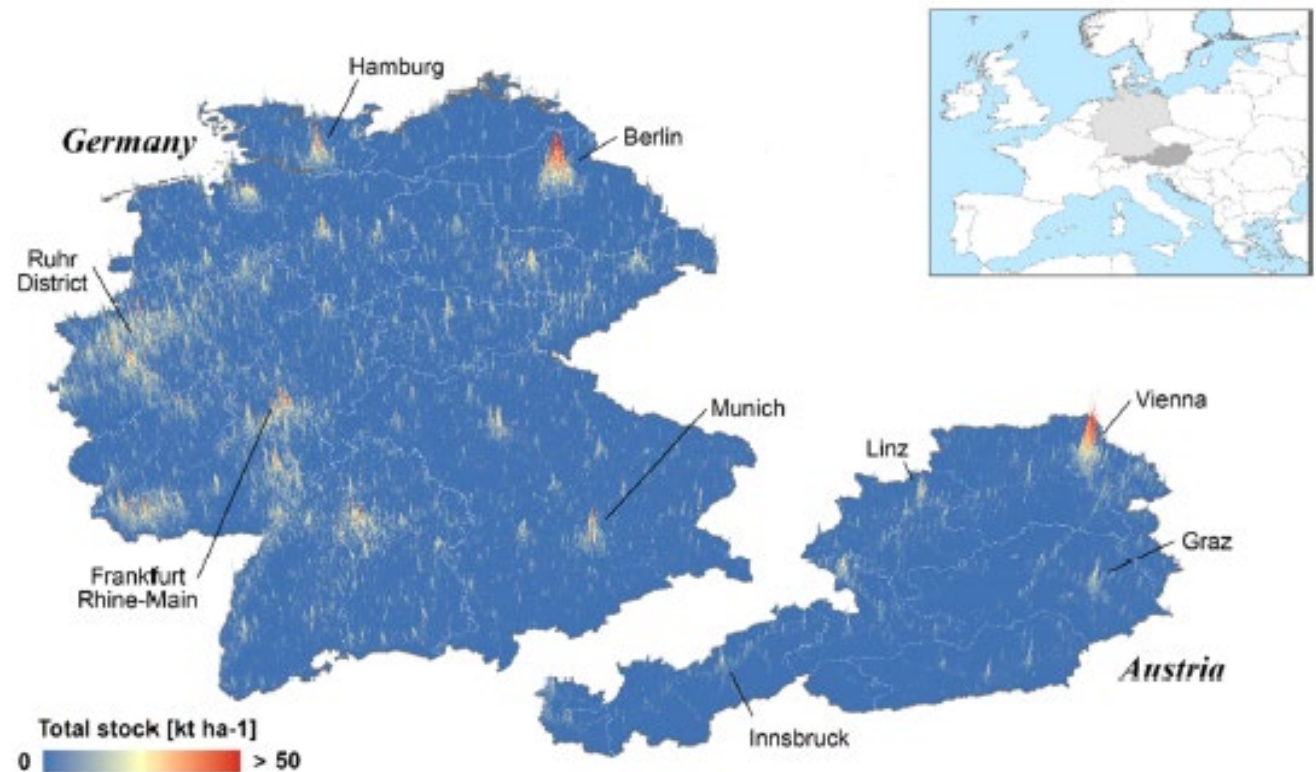
(6 types + parking)

Rails

- Railway
- 3 types of subways
- Tram
- other tracks

Bridges, tunnels

(for road, rail)



Doris Virag

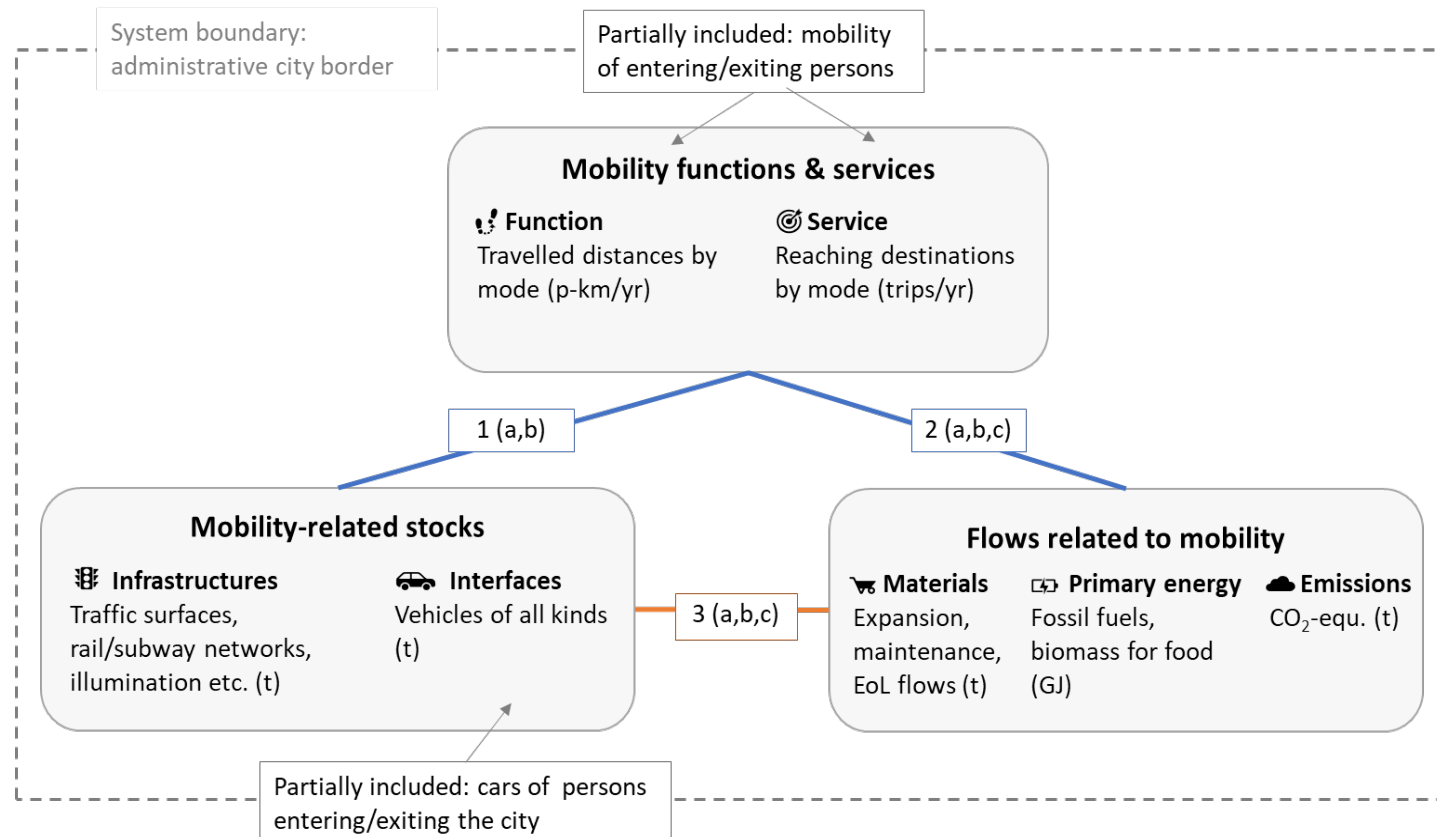
Stock-driven mapping & SFS Nexus

(2) Stock-flow-service nexus: the case study of Vienna

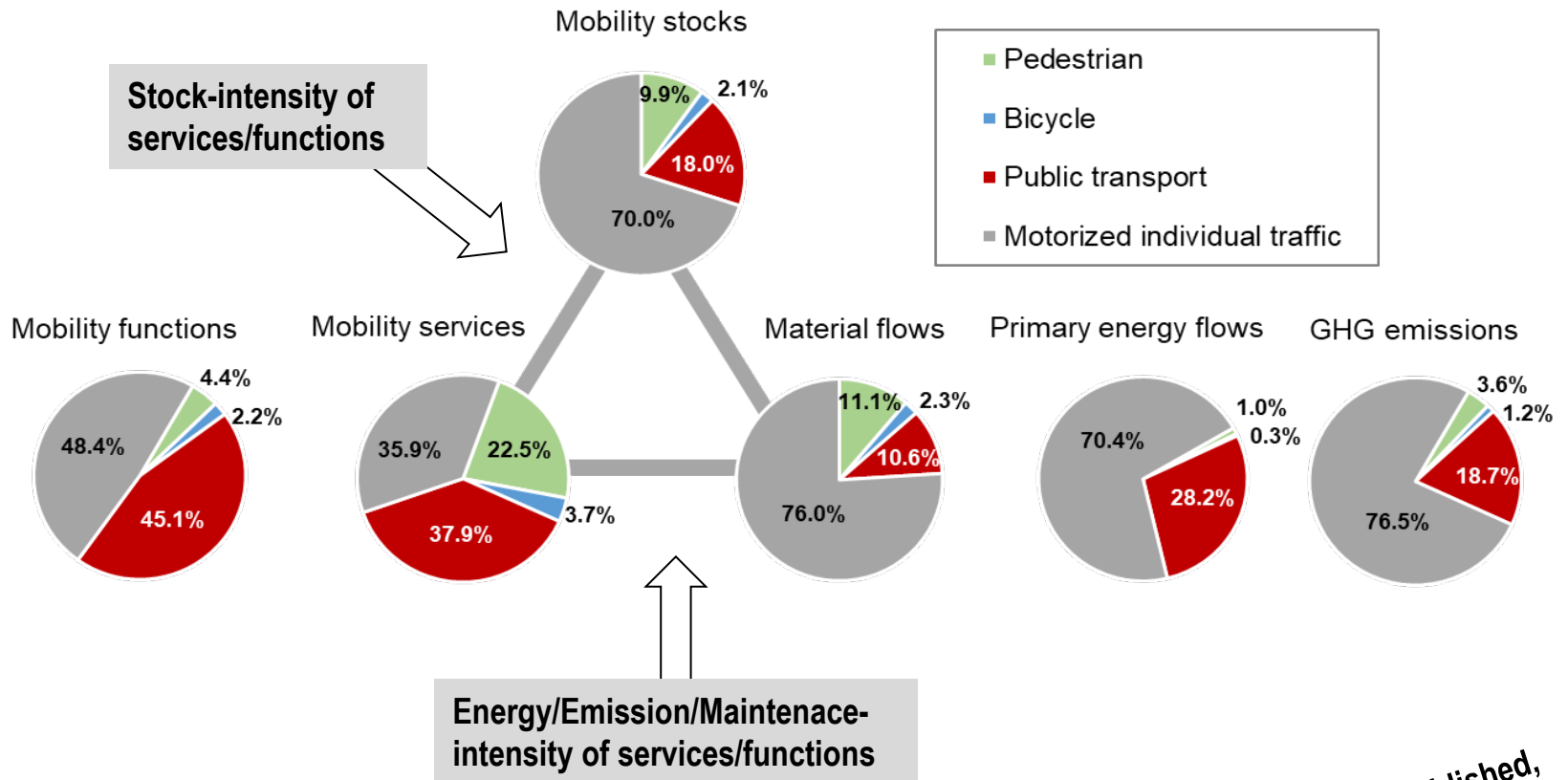
The Stock-flow-service Nexus

A case study of urban mobility in Vienna

Combination of a stock-driven / bottom up analysis of material stocks, different flows and mobility data to get a stock-flow-service nexus perspective



Stock-flow-service relations of mobility modes



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THANKS FOR LISTENING!

LITERATURE



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PICTURES



Cement brick: <https://www.buildbase.co.uk/masterblock-solid-concrete-block-7n-02801999L.jpg>

Cement house: <https://www.designboom.com/architecture/huse-vacation-house-in-vitznau-by-lischer-partner-architekten/>

Cement bridge: <https://ww1.prweb.com/prfiles/2006/02/18/348766/Jamestownbridge1.jpg>

