MEASURING THE QUALITY OF AIR TRANSPORT NETWORKS

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presenting joined work with
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UHASSELT

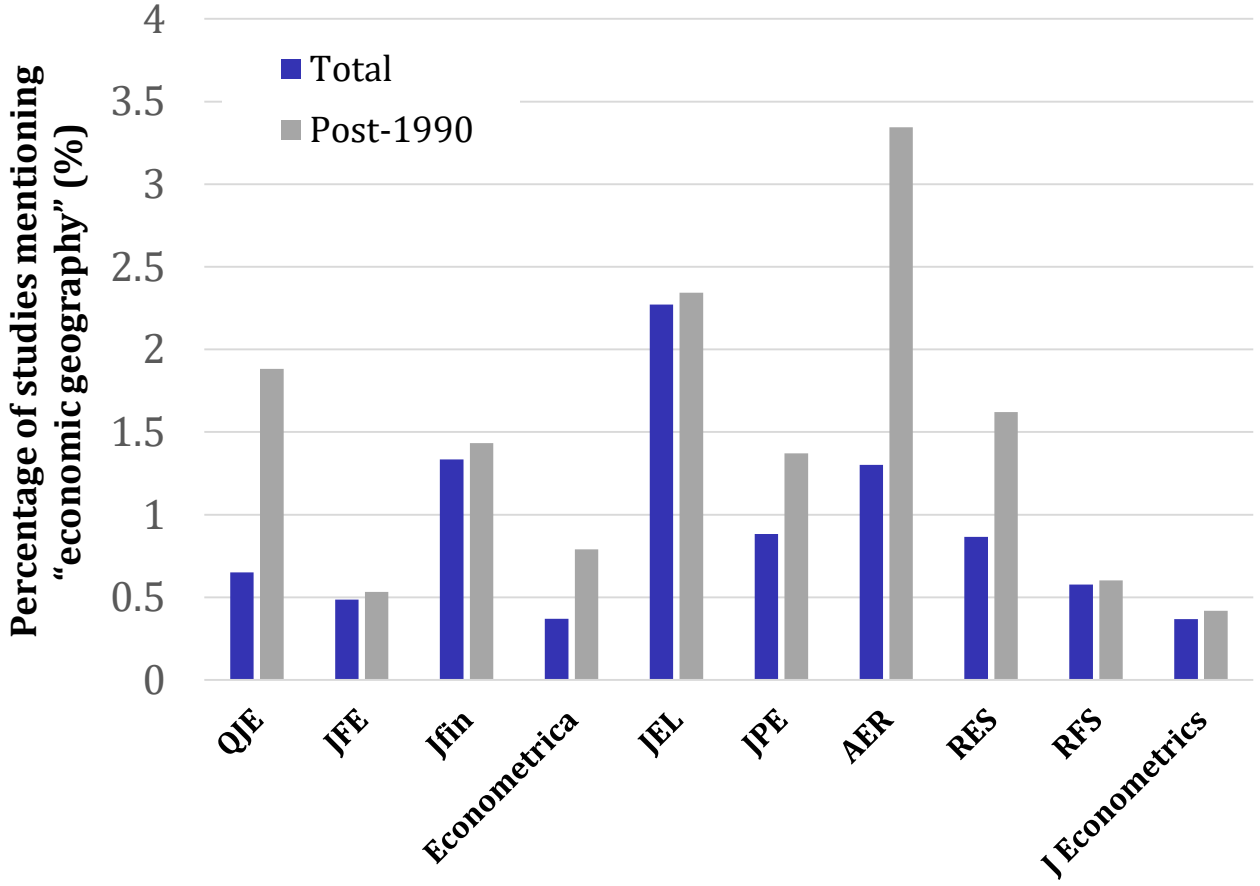
Aims

1. Discuss relationship between transport and geography
2. Definition and operationalisation of relevant metrics
3. Comparison with typical impact metrics

Economic Geography

New Economic Geography

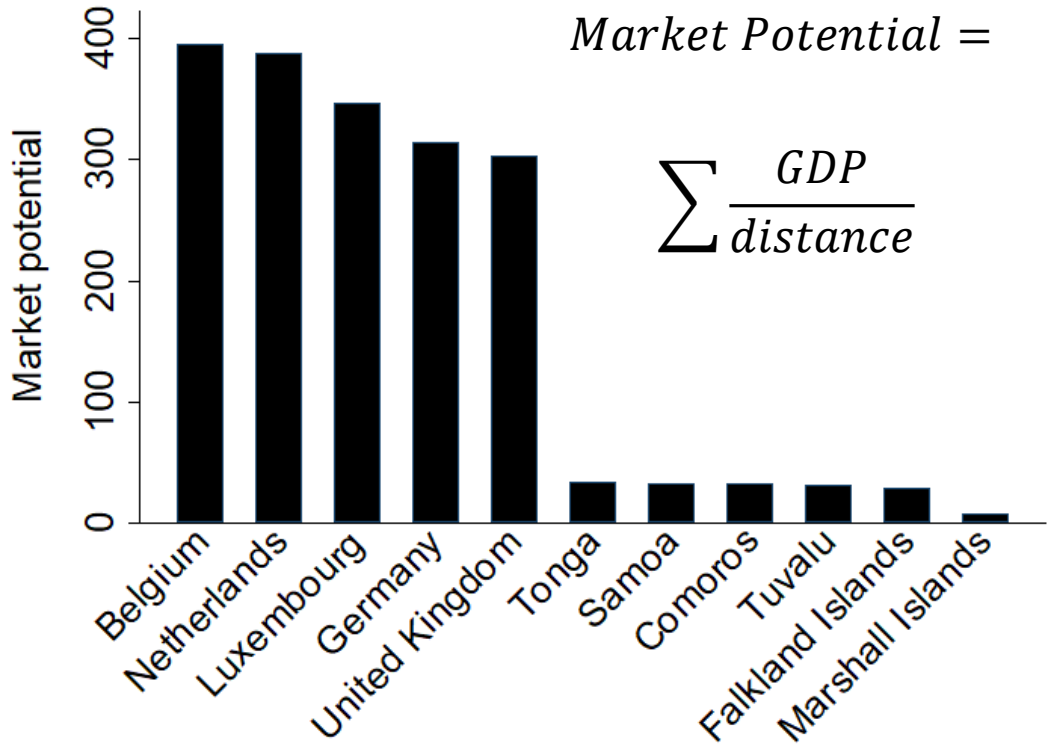
- Started in 1991 by P. Krugman
- Introduction of space and geography to economics and economic modelling
- 2008 Noble Prize on “location of economic activity"
- Empirical counterpart: Spatial Econometrics



Source: Google Scholar

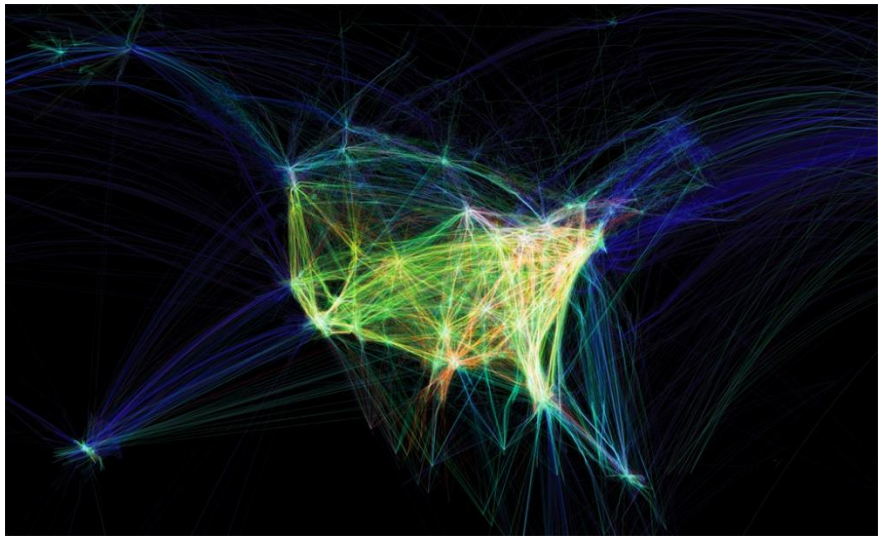
Remoteness and Transportation

Remoteness



$$Market\ Potential = \sum \frac{GDP}{distance}$$

Transportation



Source: abcblogs.abc.es

- **Transportation** is a means for **overcoming distances**
- Transportation can **compensate** geographic disadvantage (**remoteness**)

Different types of transfer cost

Type of interaction cost	**Cost determinants (physical and economic distance)**
Trade and investment cost	Institutional and policy barriers Borders Geographic contiguity
Transaction and supply chain cost	Time differences Information and communication infrastructure and services Technological barriers Cultural barriers (especially language)
Transport, travel and commuting cost	Distance Transportation infrastructure and services

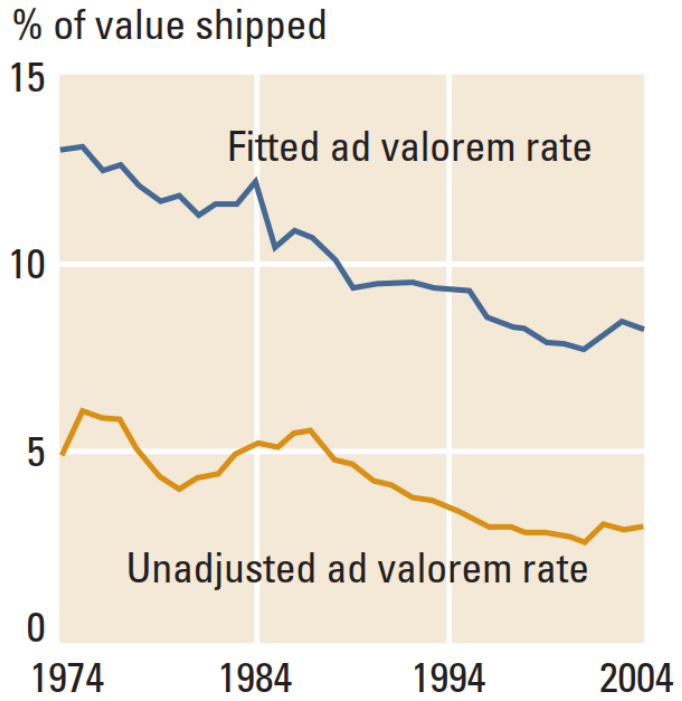
Transportation cost

Direct (monetary) costs
Ticket fare

Opportunity costs
Travel and waiting time

Disutility costs
Risk premiums, Level of comfort, Option values, Travel adjustment

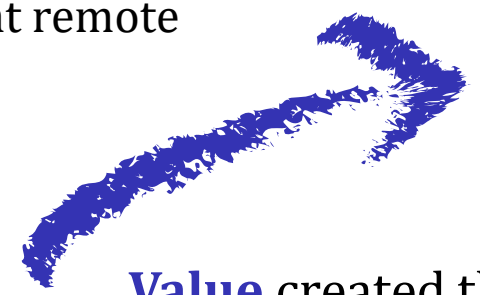
Example: cost of air freight



Source: Hummels (2007)

Interaction potential: a simplified framework

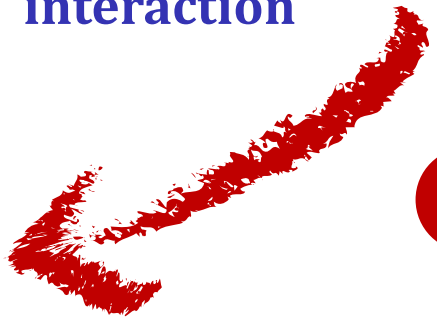
1 **Pull** by opportunities at remote markets



Remote Markets
Consumers, Producers, Suppliers, Workers

Value created through **interaction**

Home region
Consumers, Producers, Suppliers, Workers



2 **Push** by cost of overcoming frictions (distance and geography)

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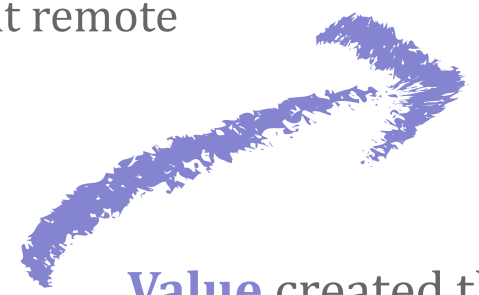

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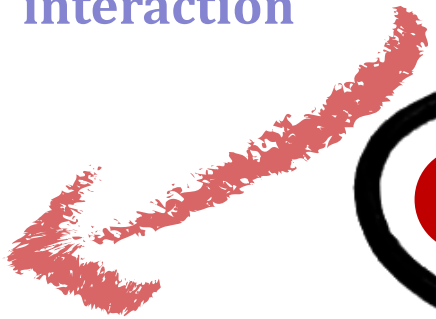

Home region
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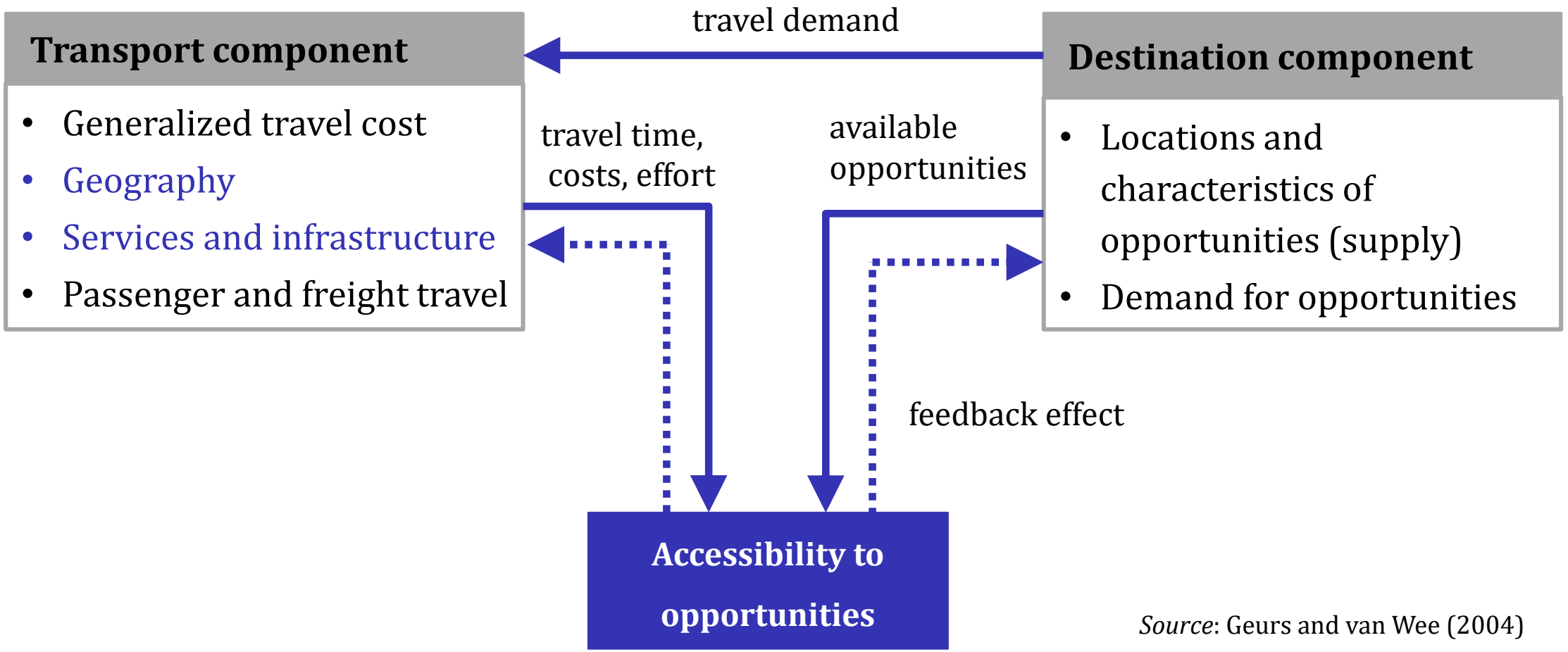
2 **Push** by cost of overcoming frictions (distance and geography)

Transport Component

Accessibility

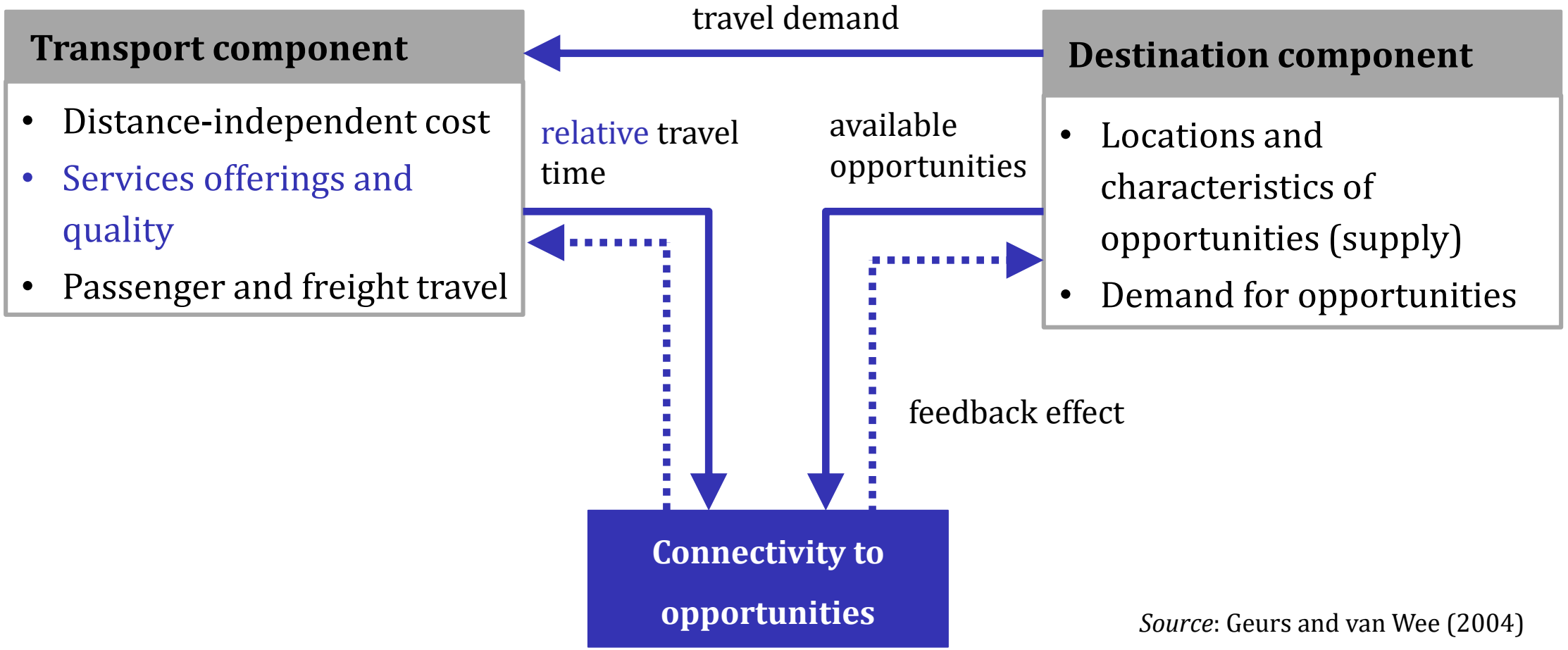
Definition
Negative function of transfer cost to, and a positive function of the market value of all destinations



Source: Geurs and van Wee (2004)

Connectivity

Definition
Negative function of transfer cost *between nodes in an aspatial network*, and a positive function of the market value of all destinations *excluding* the home market



Source: Geurs and van Wee (2004)

Summary: Decomposition of transport concepts

		Weighting of links	
		Weighted (*destination quality*)	***Invariant*** (*no destination quality*)
Spatial coverage	***Spatial*** (*generalized transportation costs*)	Accessibility	Destination-invariant Accessibility
	Aspatial (*service and infrastructure quality*)	Market Connectivity	Connectivity

Accessibility and Connectivity metrics

Operationalizing air transport metrics

Metric type	Subfamily	Definition
Connectivity-type (Aspatial)	***Centrality-type***	Number of connected airports, counted as the airports themselves or the steps on best routings only
	Feasible links	Number of feasible connections for all routings
	Link quality	Number of weighted connections for all routings
Accessibility-type (Spatial)		Measures capturing generalized air transportation costs

Link quality

Metric type	Subfamily	Definition	Examples	
			Market	*Non-market*
Connectivity-type (Aspatial)	***Centrality-type***	Number of connected airports, counted as the airports themselves or the steps on best routings only	Cristea and Danila	Closeness, degreeness, gross vertex
	Feasible links	Number of feasible connections for all routings		Doganis, Seredyński
	Link quality	Number of weighted connections for all routings	ACQI, GCI	Bootsma, Danesi, WNX, Netscan, CCI, Jenkins
Accessibility-type (Spatial)		Measures capturing generalized air transportation costs	ACI, PATH theorem	Quickest path length

Airport Connectivity Quality Index (ACQI)

- Wittman and Swelbar (2013)
- Market connectivity link quality-type
- $CON = \sum_r \delta_r \cdot w_{d_r} + \alpha \sum_{r'} \delta_{r'} \cdot w_{d_{r'}}$

  with $\delta_r = \begin{cases} 1 \text{ if direct flight} \\ 0 \text{ else} \end{cases}$

  and analogue for onestop connections (r')
- Destination weighting based on socio-economic importance of each destination proxied by hub status.

Link quality

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Netscan

- Veldhuis (1997) & De Wit et al. (2009)
- Non-market connectivity link quality-type
- Perceived travel time
- Excess travel time
- $CON = \sum_r \alpha_r \cdot f_r$
  - α_r: f(Excess travel time) $\rightarrow$ [0,1]
  - f_r: frequency

Link quality

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Global Connectivity Index (GCI)

- Allroggen et al. (2015)
- Market connectivity link quality-type
- Perceived travel time
- Detour factor
- $CON = \sum_r \alpha_r \cdot f_r \cdot w_{d_r}$
  - α_r: f(Detour factor) $\rightarrow [0,1]$
  - f_r: frequency
  - w_{d_r}: Destination weighing based on population and income

Link quality

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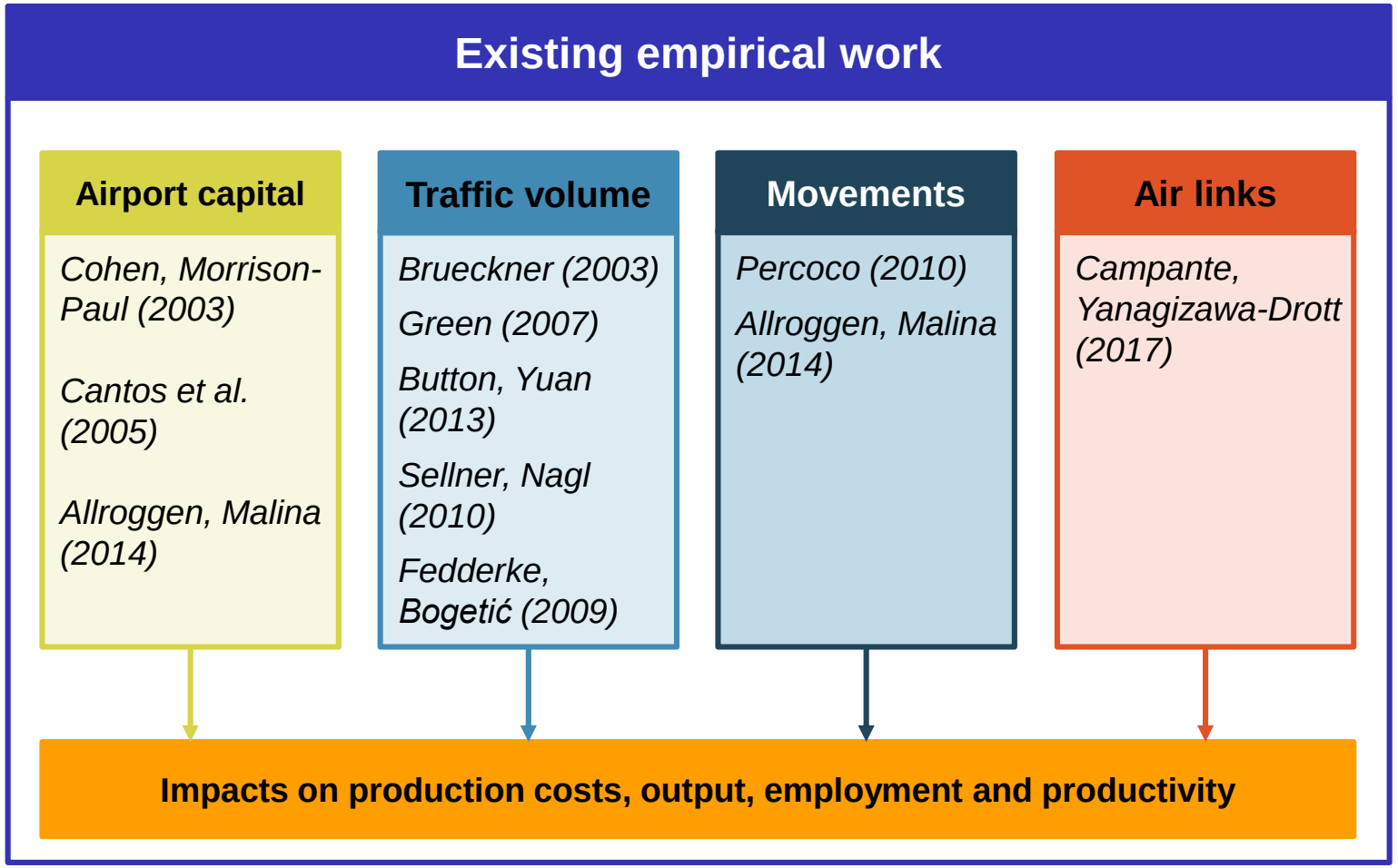
Path aggregation theorem (PATH)

- Mandel et al. (2017)
- Extension of Bootsma connectivity
- Additional weights based on OD path utilities (path choice model)
- No a priori quality weights assumptions but passenger preferences, incl. ticket prices

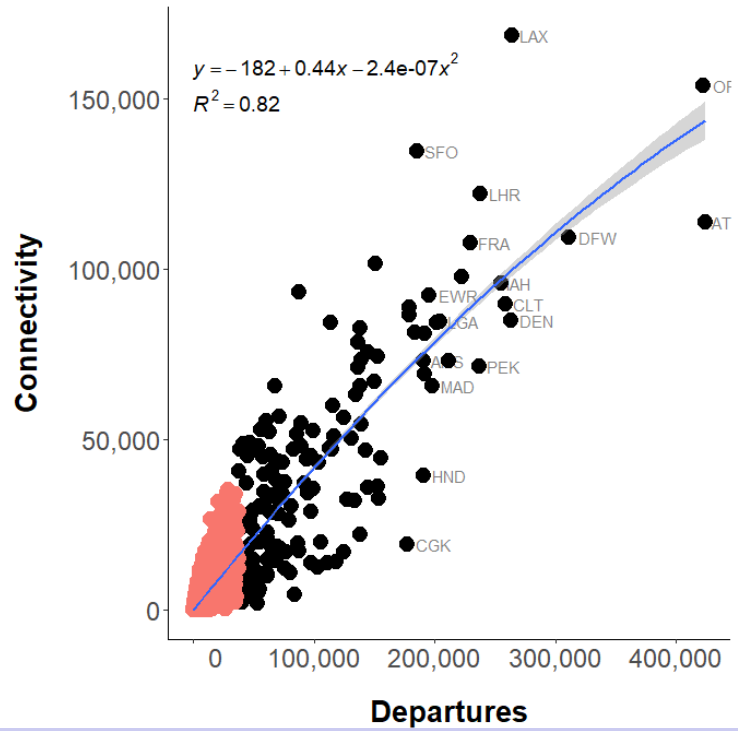
Implications for impact assessment

Empirical evidence on the economic impacts of aviation



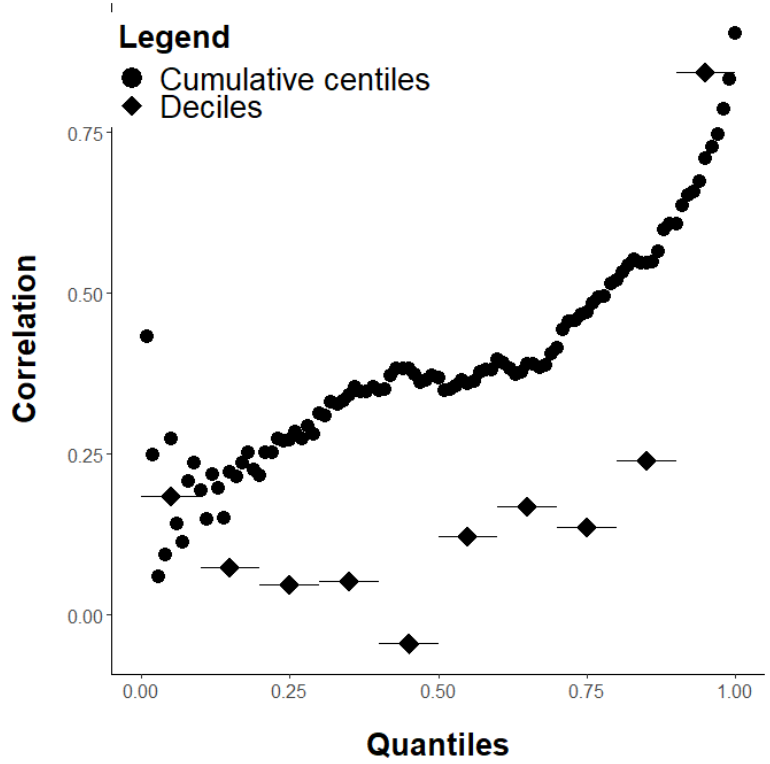
Connectivity vs Departures

Trend line
Global, year 2012



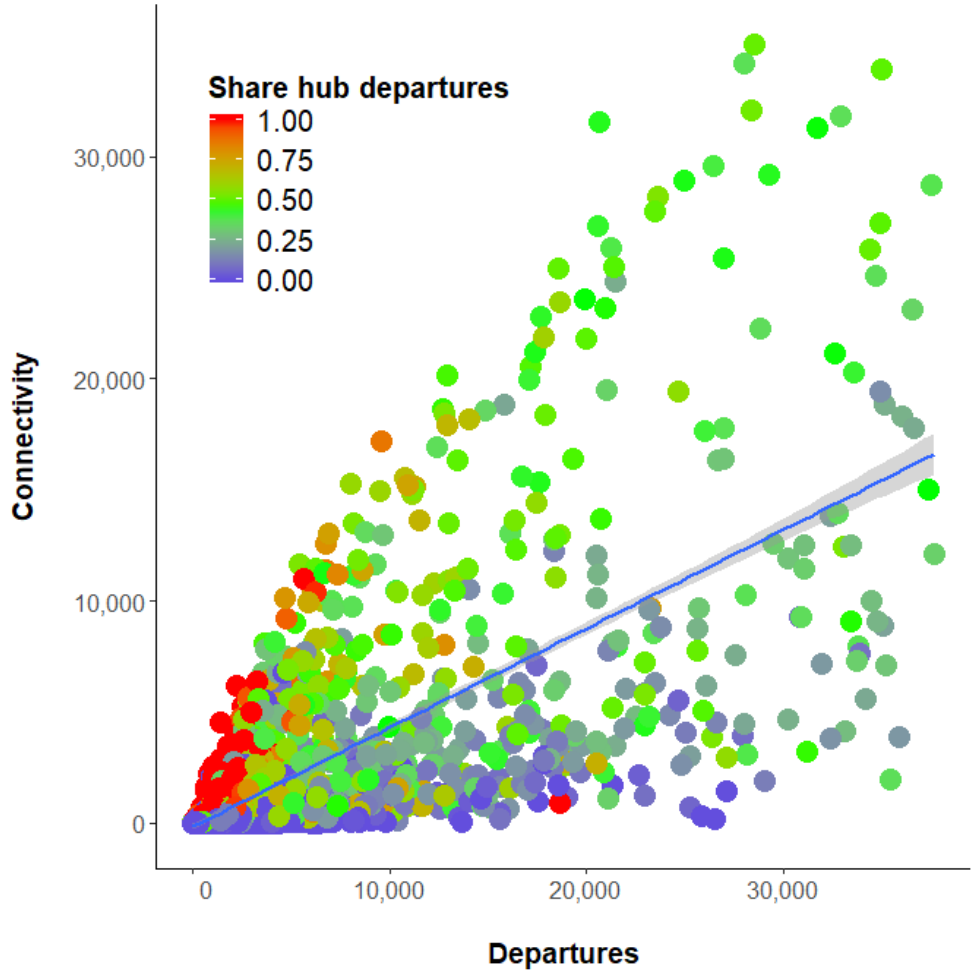
- Very rough trend present
- Large amount of outliers

Correlation,
Global, year 2012



- Local correlation weak, overall correlation driven by outliers

Connectivity vs Departures (2)



Network structure

- Traffic statistics do not capture network structure
- Importance of indirect connections: many small airports rely on onward connectivity
- **Connectivity metrics needed** to value access through network

Conclusions

- Connectivity and accessibility are essential for **measuring** and understanding the **benefits** of air transport
- **Connectivity:** aspatial cost
  - Measures level of services offerings and quality
  - Determines transportation's ability to **overcome distance**
- **Market potential:** (purely) spatial cost
  - Measures remoteness/centrality
- **Accessibility**: overall cost
  - Measures (net) interaction cost, but no separation between transport and space
  - Determines geographical **distribution of economic activity**
- **Dilemma** between accessibility and connectivity/market potential

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