(Hansen 1959): “potential of opportunities for interaction”

$$S_i = \sum_j O_j \cdot f(c_{ij})$$

A Family of Accessibility Measures:

Bringing the units back

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Deciphering accessibility scores:

$$S_i = \sum_j O_j \cdot f(c_{ij})$$

The problem:

- What does the accessibility score mean? The units are uninterpretable!

A solution:

- (Re)introducing proportionality constants to bring units back to accessibility

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Evolution of gravity-based accessibility: what about G?

Newton's Law of Universal Gravitation

$$F_{ij} \propto \frac{M_i M_j}{D_{ij}^2}$$

$$F_{ij} = G\frac{M_i M_j}{D_{ij}^2}$$

(Carey, 1859), from physics to social science

(Stewart 1947), sets G = 1 and defined "Population Potential" (V):

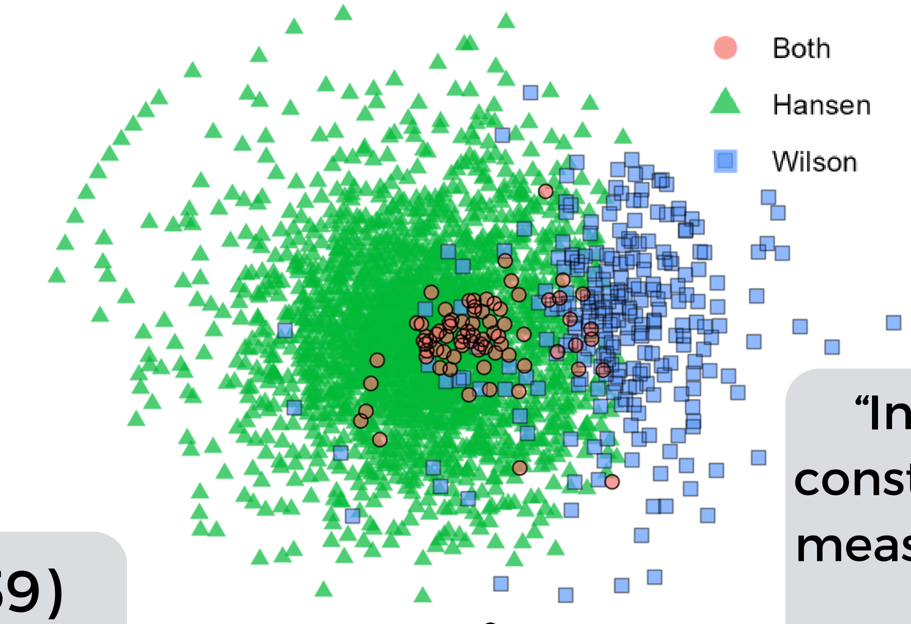
$$V_i = G\sum_j \frac{M_j}{d_{ij}}$$

(Hansen 1959)

$$S_i = \sum_j O_j \cdot d_{ij}^{\beta}$$

"The Family of Gravity Models" (Wilson 1971)

$$T_{ij} = kW_i^{(1)} W_j^{(2)} f(c_{ij})$$



"Introducing singly-constrained accessibility measure" (Soukhov et al. 2023)

"A family of accessibility measures" (Soukhov et al., forthcoming)

1687 — 1798 — 1940-1959 — 1970 — TODAY

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A “family” of accessibility measures

Gravity model’s formulation:

$$T_{ij} = kW_i^{(1)}W_j^{(2)}f(c_{ij}) \longrightarrow V_{ij} = kO_jf(c_{ij})$$

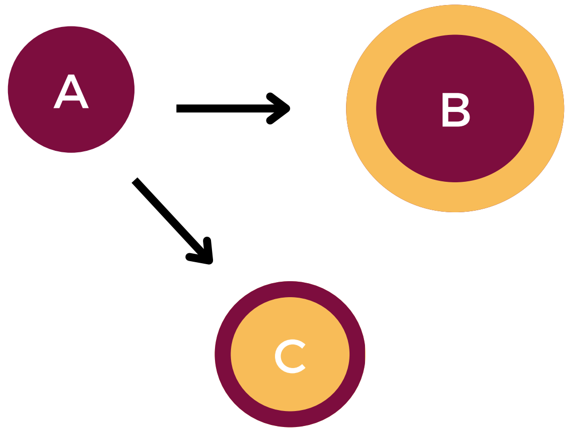
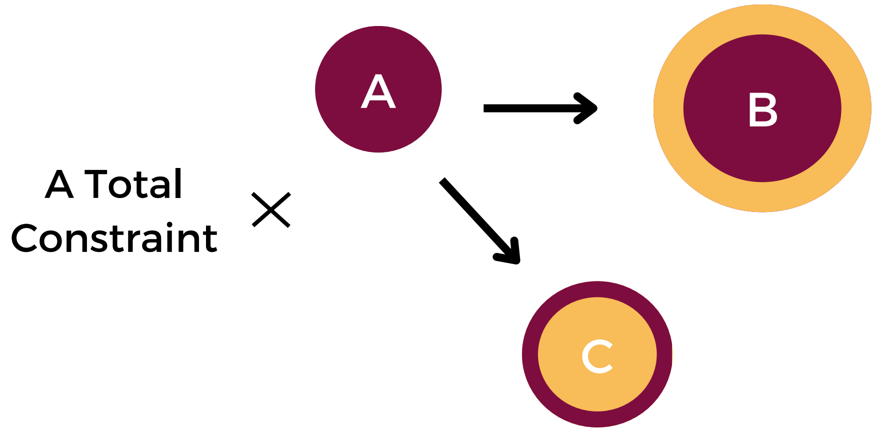
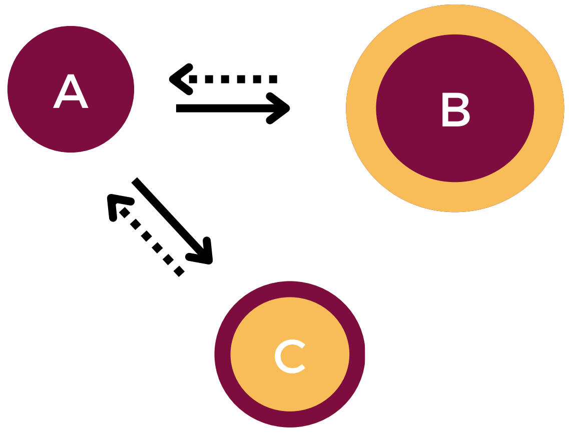
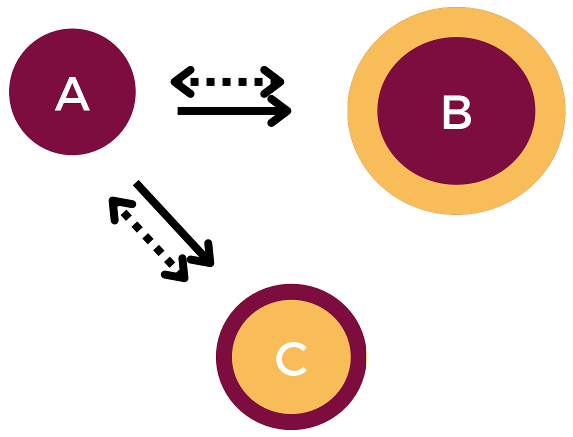
$$V_i = k\sum_j O_jf(c_{ij})$$

$$W_i^{(1)} \rightarrow P_i$$

$$W_j^{(2)} \rightarrow O_j$$

k is a set of balancing factors defined by zonal/region constraints.

Proportionality constraints in accessibility matter:

Unconstrained **(all people to all jobs)**	**Total Constrained** **(all people to all jobs; balanced)**	**Singly-constrained** **(all people to jobs at each zone)**	**Doubly-constrained** **(people at each zone to jobs at each zone)**
			
1,000 'accessible' jobs at A	100 accessible jobs at A (out of 500)	200 accessible jobs at A (out of 500)	250 accessible jobs at A (out of 500)

By balancing the units, an accessibility "family" framework can add:

1. Enhanced interpretation,
2. Comparability across spatial and temporal cases
3. Robustness to spatial analysis (e.g., Vi adds up to 100%)

$$V_i = k \sum_j O_j f(c_{ij})$$

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A “family” of accessibility measures

$$V_{ij} = kO_j f(c_{ij})$$

$$V_i = k\sum_j O_j f(c_{ij})$$

k is a set of balancing factors defined by zonal/region constraints.

$$\sum_i \sum_j V_{ij} = V$$ → 1) Total constraint

$$\sum_i V_{ij} = O_j$$ → 2) Opportunity constraint

$$\sum_j V_{ij} = P_i$$ → 3) Population constraint

Unconstrained case (neither constraint 1, 2, or 3)

- Current practice

Total constrained case (constraint 1)

Singly-constrained case (constraint 1 and 2)

- e.g., spatial availability measure (Soukhov et al., 2023, 2024, 2024)

$$k = B_{ij} = \frac{P_i}{\sum_i P_i f(c_{ij})}$$

Doubly-constrained case (constraint 1,2, and 3)

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