Location theory and clusters

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1. Introduction

- Internal economies of scale (EofS) can lead to
  - Trading cities (EofS in transport)
  - Factory cities (EofS in production)

- But *where* do cities emerge?
  - Why is Colombo located where it is?

- And *why* are cities bigger than a single firm?

1. Introduction

- We will discuss models that try to explain the formation of cities
  - Weber's location choice model
  - Hotelling's model of spatial competition
  - Central place theory
- Discuss agglomeration economies and clusters and some empirical evidence
- But first: the principle of median location

1. Introduction

- **Structure**

2. **Principle of median location**
3. **Weber's location choice model**
4. **Hotelling's model of spatial competition**
5. **Central place theory**
6. **Internal vs. external returns to scale**
7. **Sources of agglomeration economies**
8. **Empirical evidence**
9. **Summary**

Location theory' / Agglomeration economies

2. Principle of median location

- Example: pizza delivery service ("Ann") is looking for optimal location
  - Inputs have the same price everywhere, independent of location
  - Price of pizza's is given
  - Every consumer demands 1 pizza per day
  - Every pizza requires a separate trip
  - Ann bears delivery cost: $1/km (return)
  - Customers live along a single road, and are distributed as follows:

	A	B	C	D						E	
km	0	1	2	3						9	
#	2	8	1	0						10	

2. Principle of median location

- **Example: pizza delivery service ("Antonio") is looking for optimal location**

- **What is the optimal location?**
- **What is the optimal location if E would be at 100km?**
- **What if location E had 50 customers instead of 10?**

	A	B	C	D						E	
km	0	1	2	3						9	
#	2	8	1	0						10	

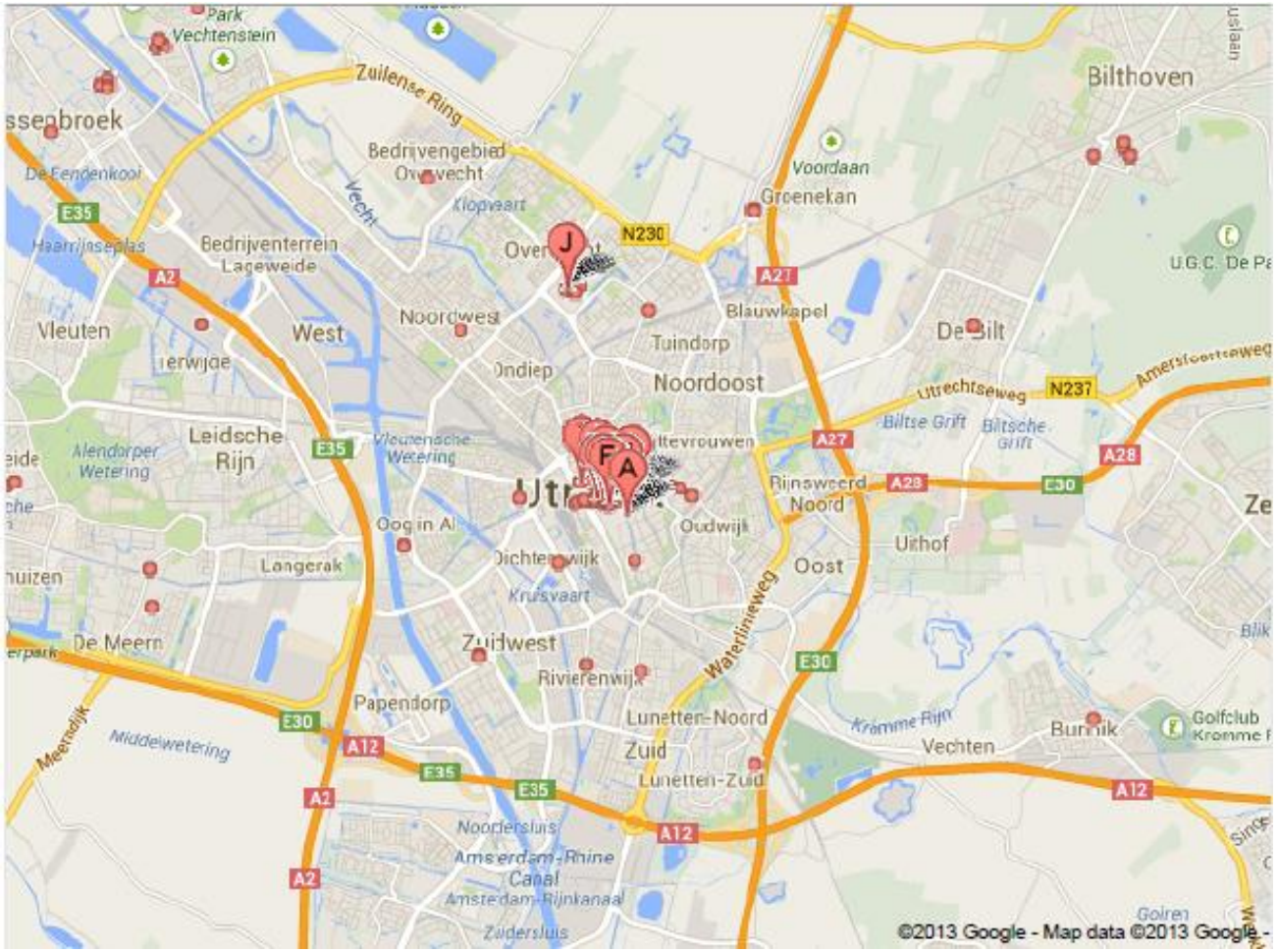
2. Principle of median location

- **Median location: equal number of customers to the left and right**
  - **Otherwise: a 1 meter move away from the median location will increase distance to the majority of the consumers, so the total delivery distance increases**

	A	B	C	D						E	
km	0	1	2	3						9	
#	2	8	1	0						10	

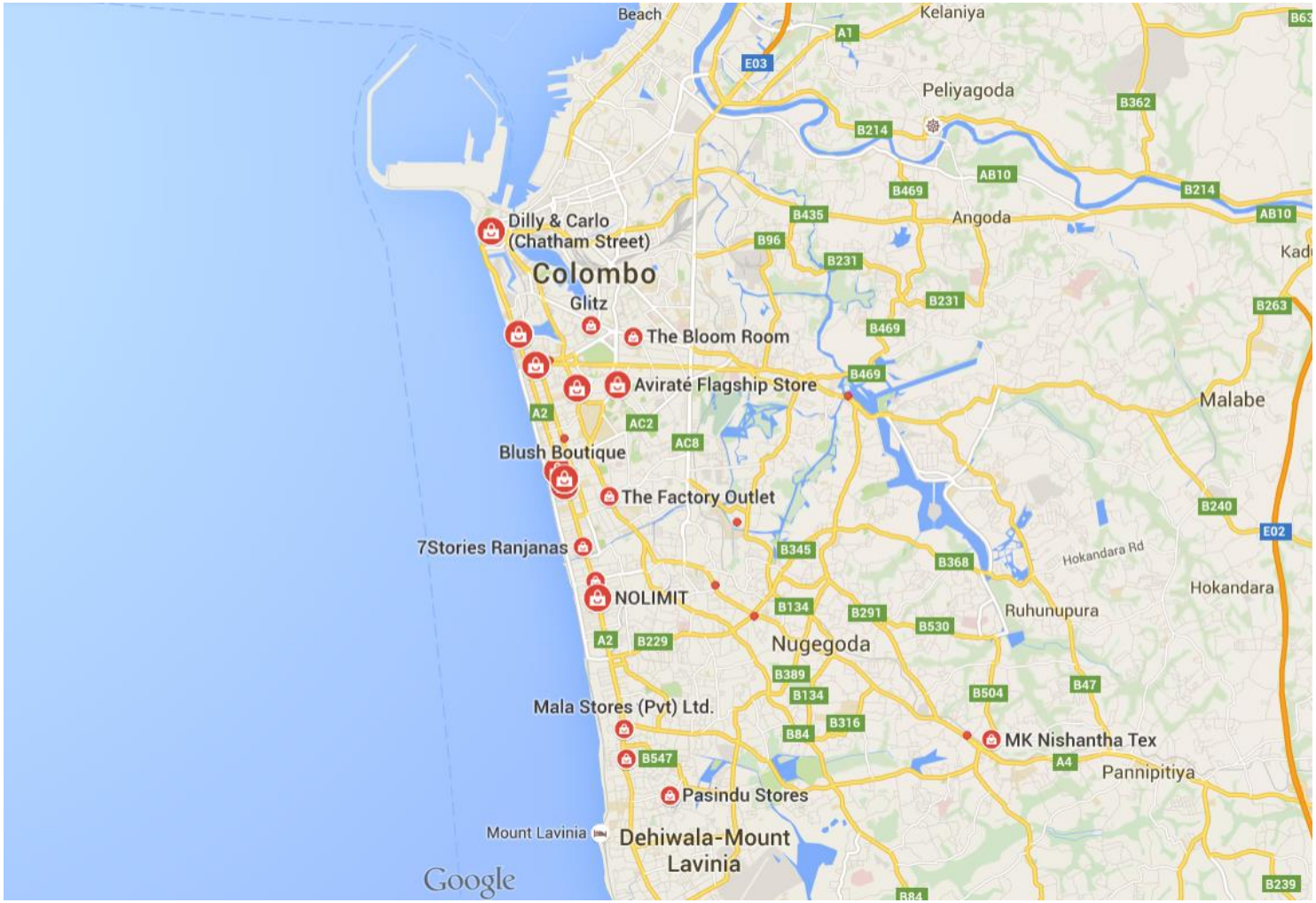
2. Principle of median location

- **Example: shoe shops in Utrecht, the Netherlands**



2. Principle of median location

- **Example: clothing stores in Colombo**



3. Weber's location choice model

- **Transport-oriented firms: Weber (1909) approach**

- **A classic model that makes 4 assumptions**
  1. **1 transferable output, for a single market M**
  2. **1 transferable input, from a single source S**
  3. **Given output level, and fixed factor proportions**
  4. **Fixed prices**

- **Firm maximizes profit by minimizing transport costs**
  - **Procurement cost *(for getting inputs to factory)***
  - **Distribution cost *(for getting outputs to market)***

- **Key concept: monetary weight**
  - $physical\ weight \times transport\ rate$ **(per tonne km)**
  - **Note: physical weights should be comparable in the sense of referring to the same level of output**

3. Weber's location choice model

- **The firm locates somewhere between *S* and *M***

	Input (wood)	Output (bats)
Physical weight (tonnes)	4	1
Transport rate ($ / tonne / km)	$1	$2
Monetary weight	$4	$2

- **Distance between *S* and *M*: 10 km**
- **Output are 10 units of bats**

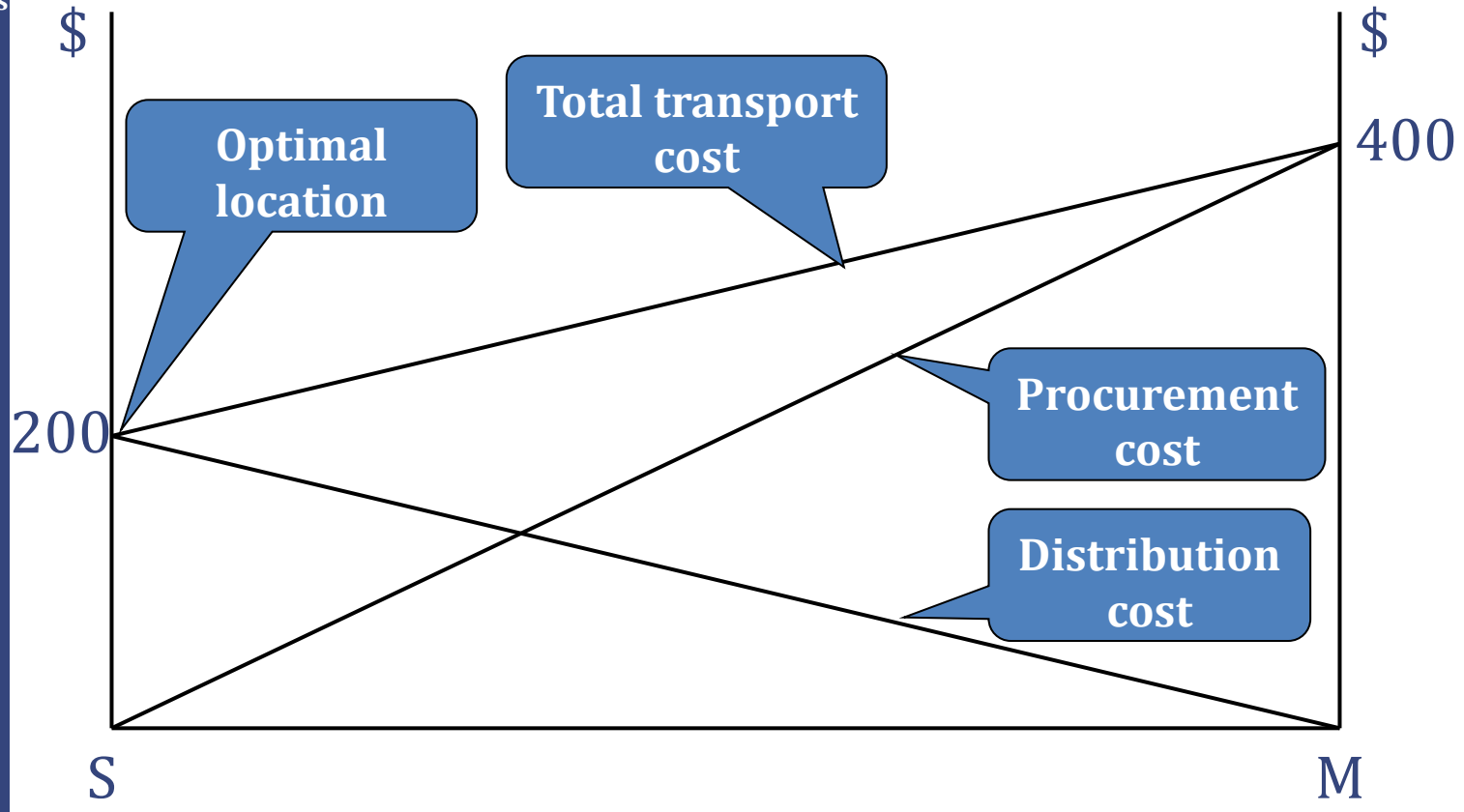
- **Draw in a diagram: distribution cost, procurement cost, and total transport cost (per tonne of bats) as a function of location**
- **Determine optimal location**

3. Weber's location choice model

- **Transport-oriented firms: Weber (1909) approach**

3. Weber's location choice model

- **Transport-oriented firms: Weber (1909) approach**



3. Weber's location choice model

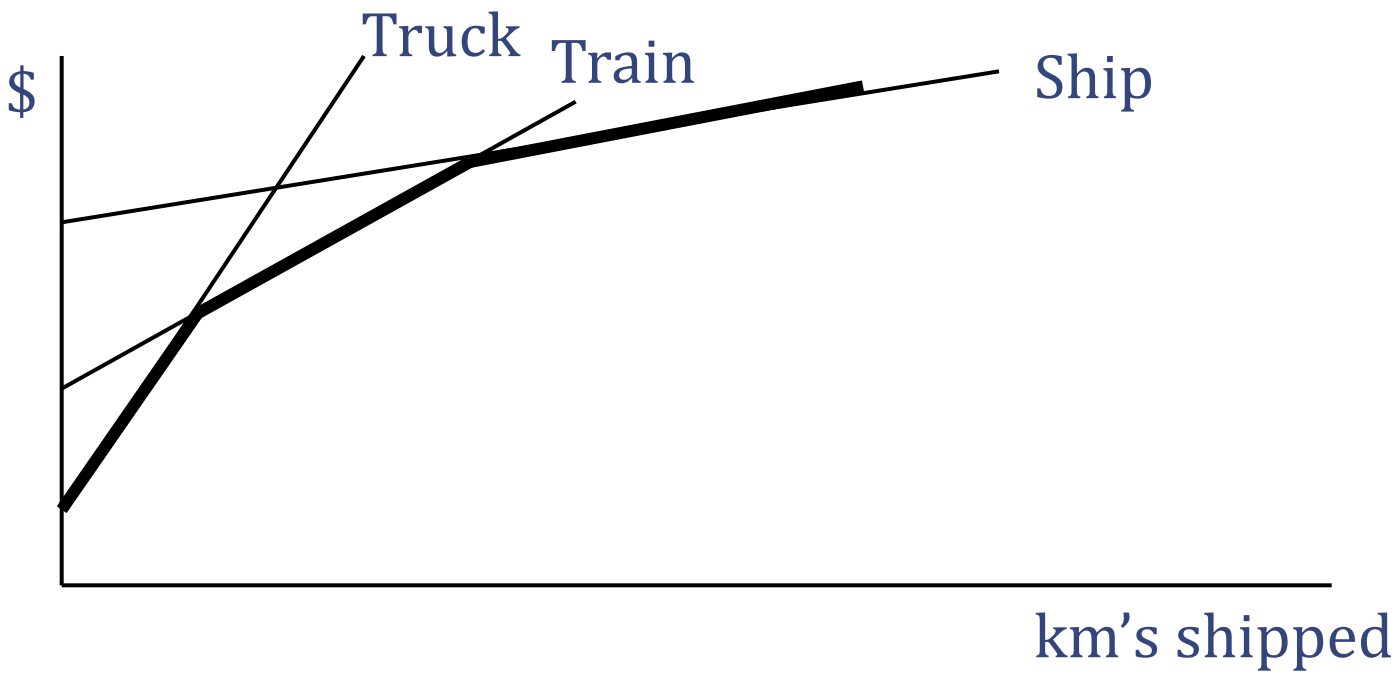
- **Baseball production is 'resource oriented' because it is 'weight losing'**
  - **Other reasons to be resource oriented:**
  - **Perishable inputs *(milk, wine)***
  - **Volume losing *(cotton baling)***
  - **Fragile / hazardous inputs *(skunk deodorizing)***

- **Market oriented location with:**
  - **Weight gaining *(beer)***
  - **Perishable outputs *(bread)***
  - **Volume gaining *(automobile assembly)***
  - **Hazardous output *(weapons)***

- **Under our assumptions: (nearly) always a location at an end-point**

3. Weber's location choice model

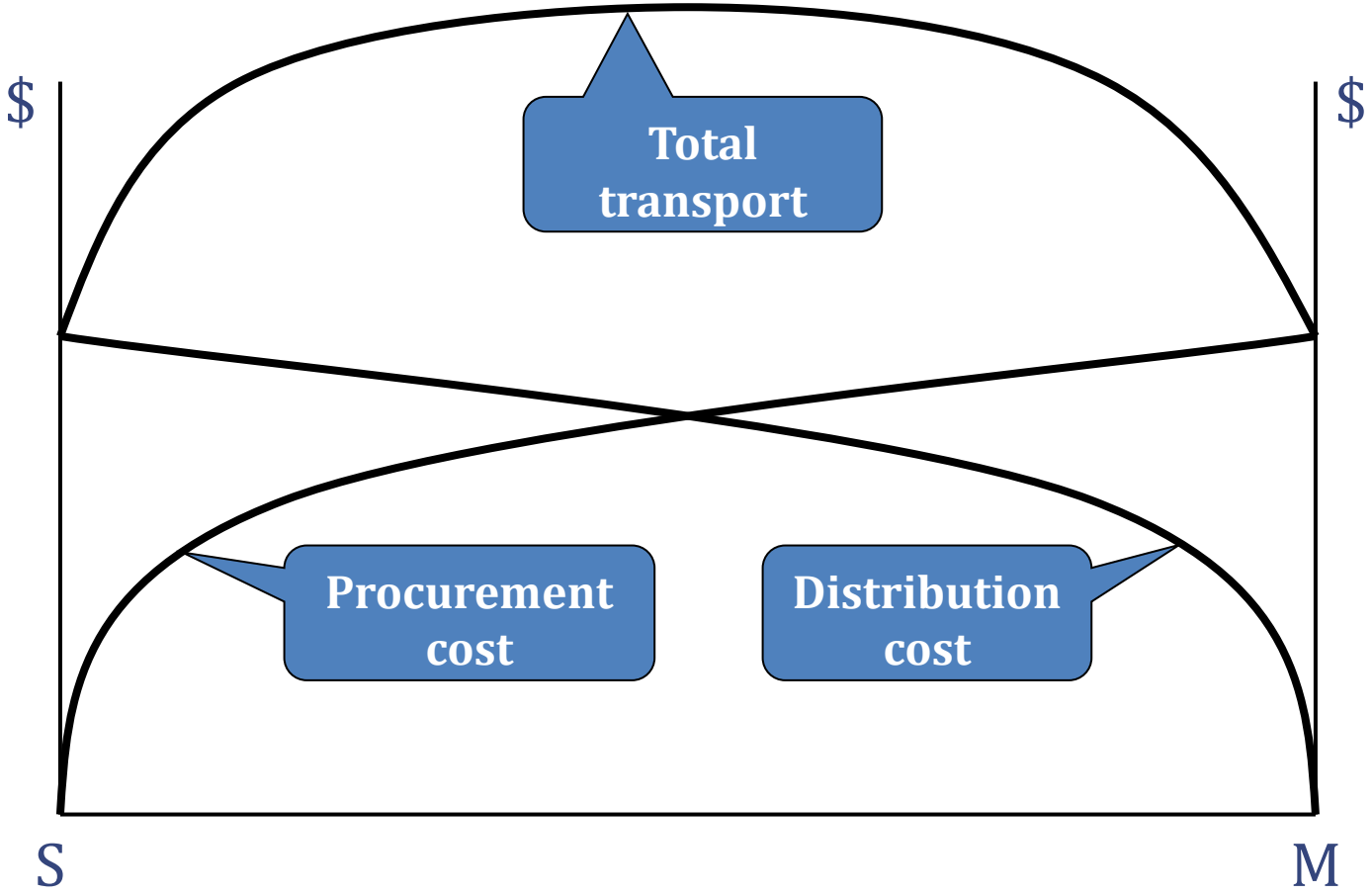
- **Non-linear transport costs**
  - **e.g. modal choice**



Q How would this affect location? Does orientation towards end-points increase or decrease?

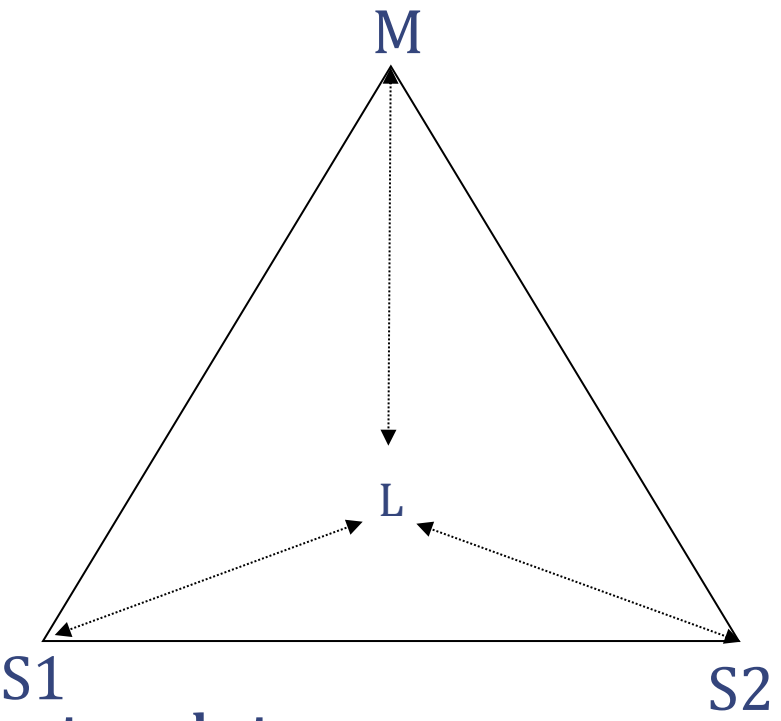
3. Weber's location choice model

- Strengthens attractiveness of endpoint locations



3. Weber's location choice model

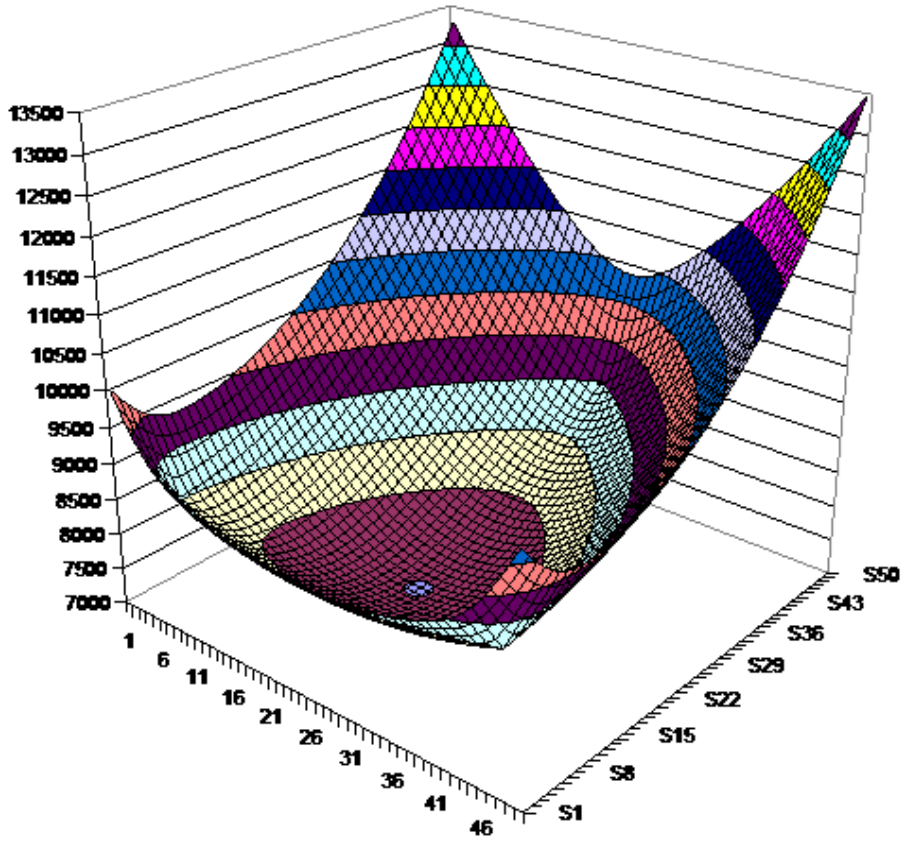
- Weber's triangular set-up



- One output market
- Two input markets
- Transport costs to each market
- Choose L such that transport costs are minimized
- Distance to corners: Pythagoras
- Multiply these distances with monetary weights
- Same principle; typically not a corner

3. Weber's location choice model

- **Three-dimensional representation**



4. Hotelling's model of spatial competition

- **Why do firms cluster?**
  - **A firm enjoys benefits that compensate for the higher cost…**

- **These benefits are:**
  - **Market share *(spatial competition)***
  - **Agglomeration economies *(next hour)***
  - **Other benefits *(next hour)***

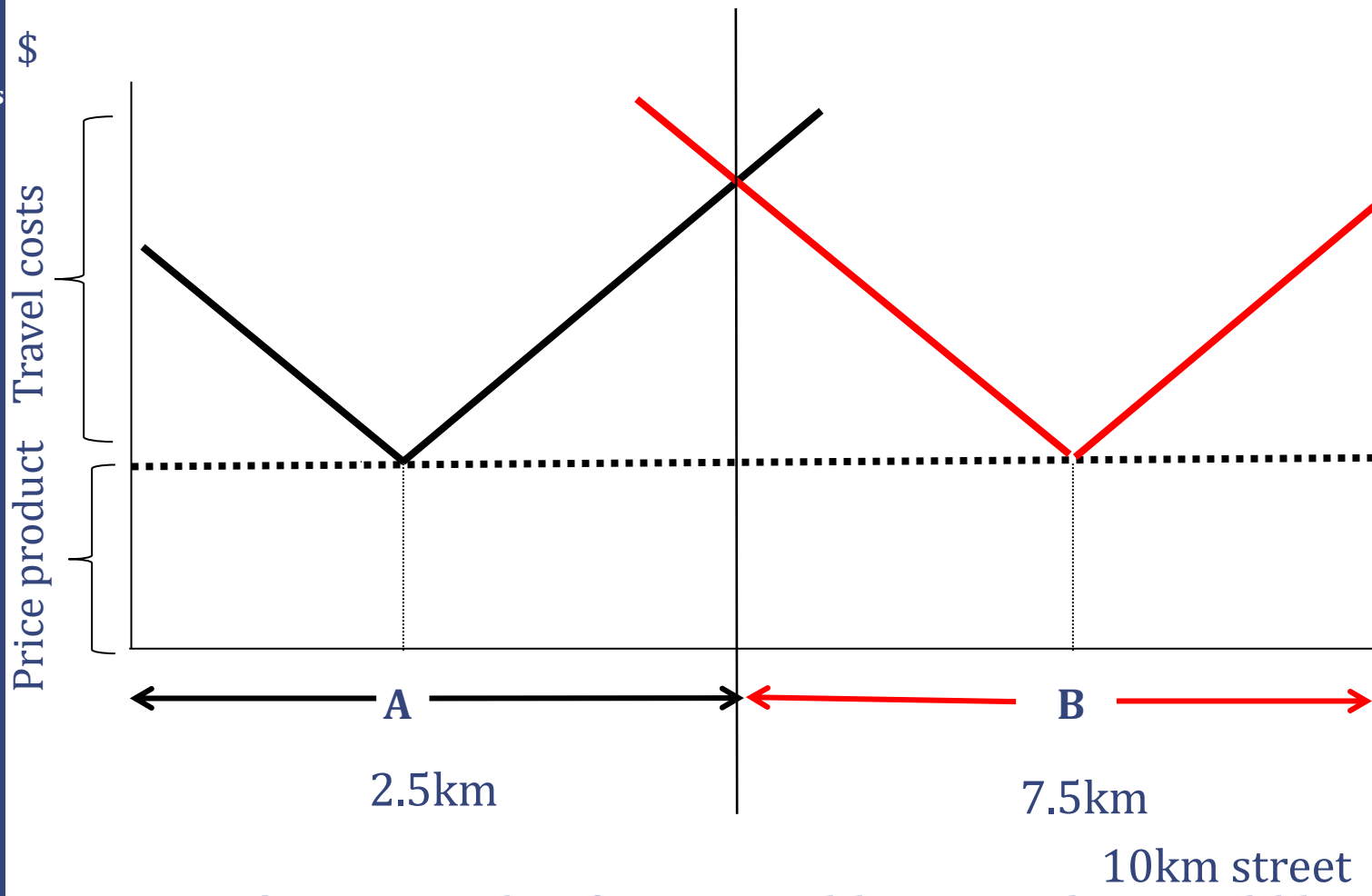
4. Hotelling's model of spatial competition

- **Can we explain the 'market share' effect with a simple economic model?**

- **Set-up of the game**
  - **2 firms: A and B**
    - → **.. in the same street**
    - → **.. selling the same product**
    - → **.. at the same fixed price**
  - **Consumers are equally distributed along the street**
  - **Consumers frequent most nearby firm**
  - $price = price\ product + travel\ time$

4. Hotelling's model of spatial competition

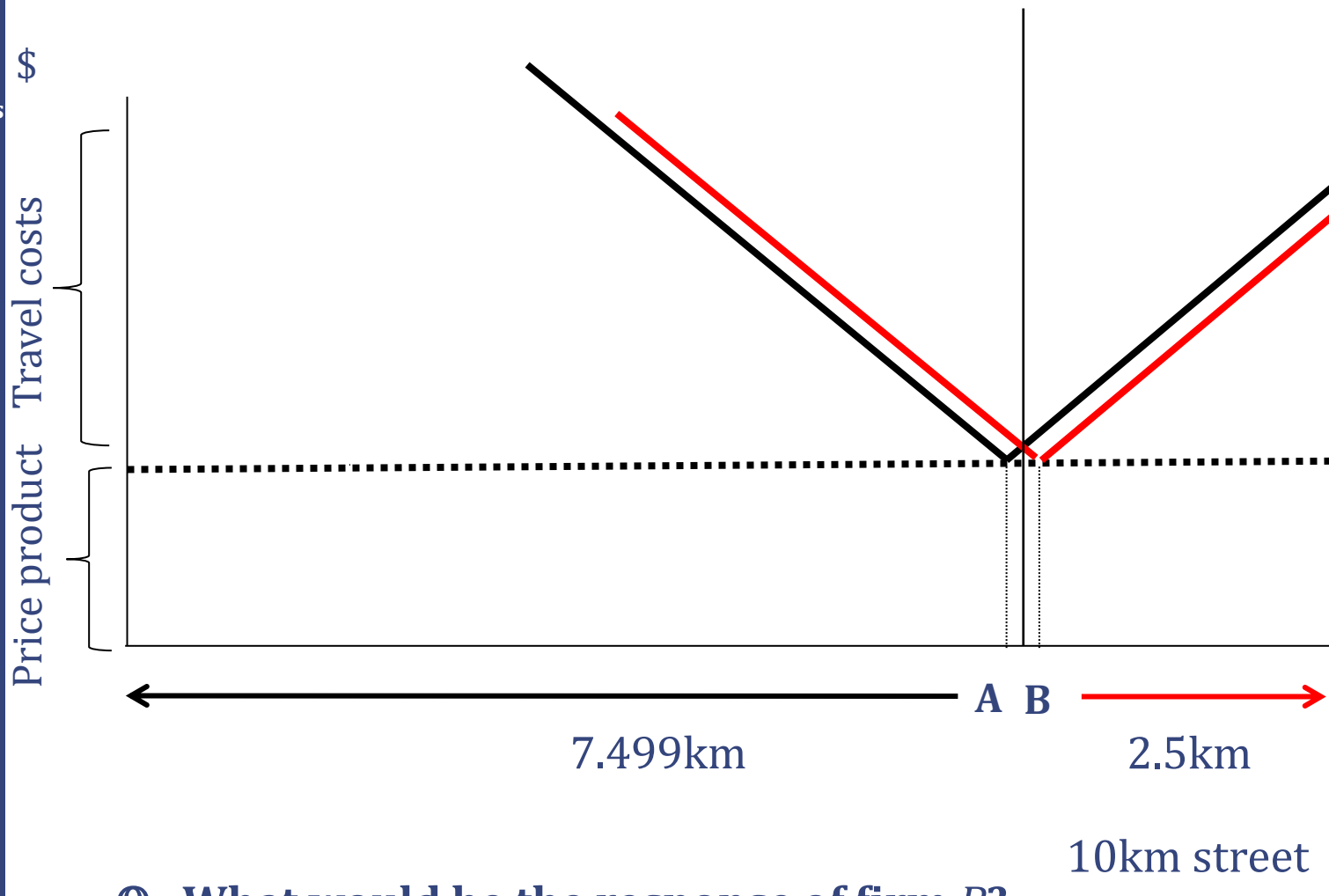
- **Initial situation**



Let's assume that firm *A* would move. What would be the profit-maximising location?

4. Hotelling's model of spatial competition

- **Firm *A* moves**

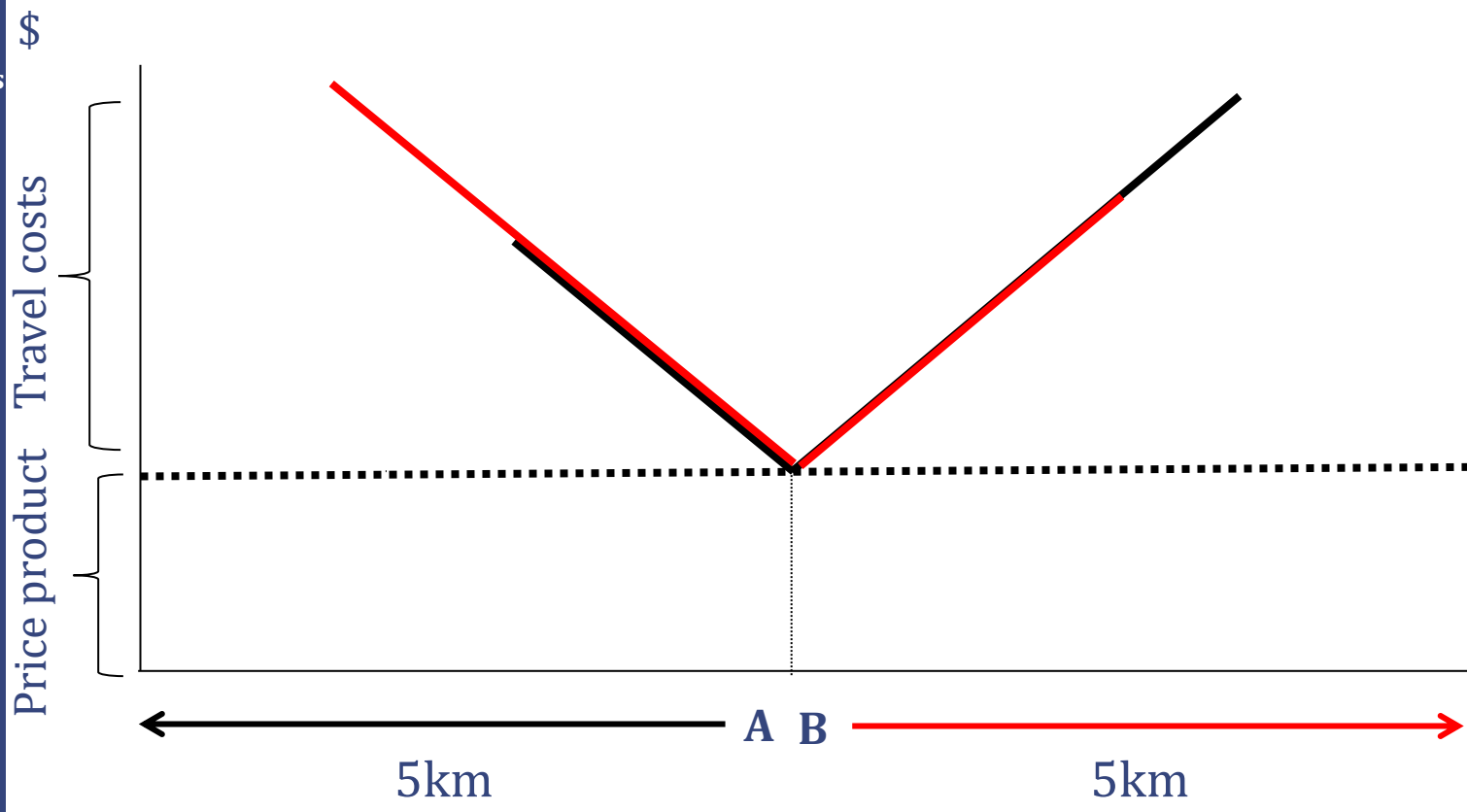


Q What would be the response of firm *B*?

Q What will be the equilibrium?

4. Hotelling's model of spatial competition

- **Final situation**



Q Is this the optimal location? I.e. are the total transport costs minimised in this situation?

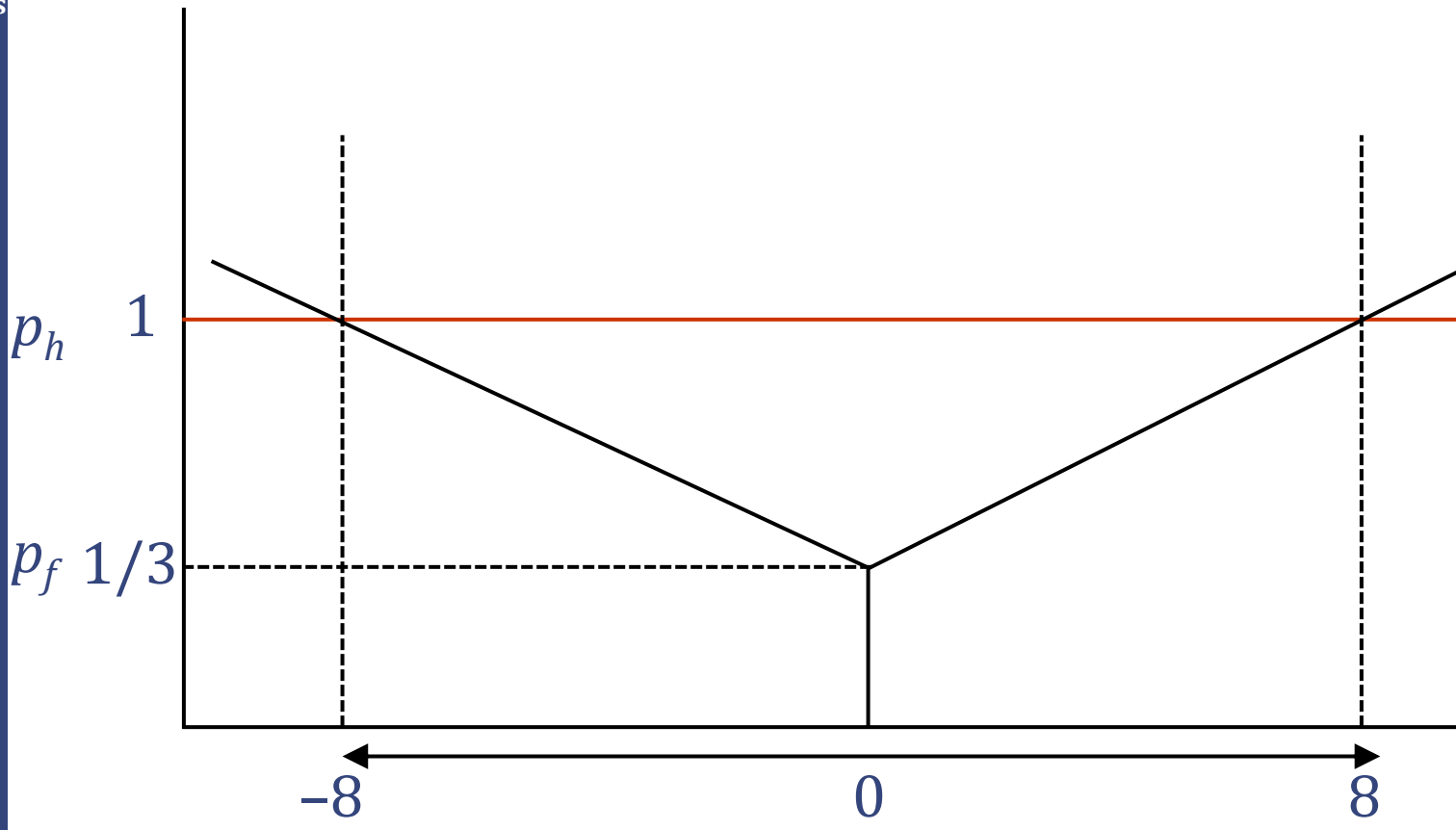
4. Hotelling's model of spatial competition

- **Hotelling result**
  - **Leads to price competition…**
  - **…unless supply of goods is heterogeneous**
    → **cars, clothing, furniture, hotels, etc.**

- **Relation with 'Principle of median location' (Ch. 2) ?**

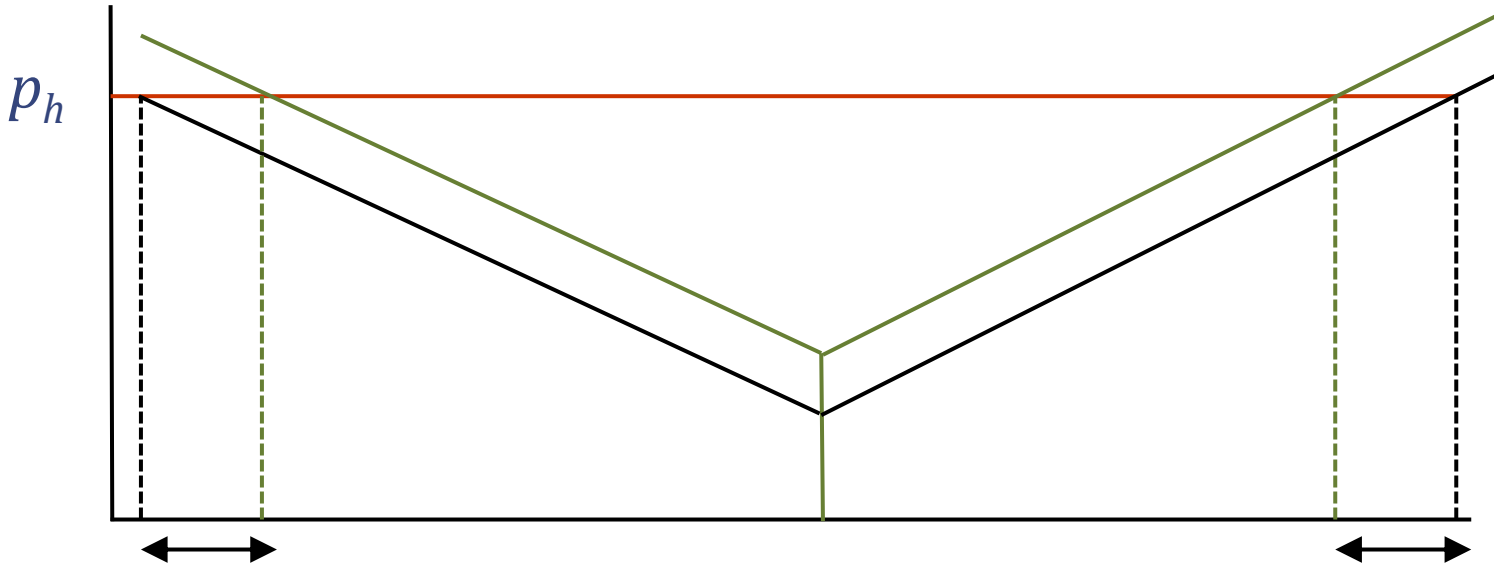
4. Hotelling's model of spatial competition

- **Market area**



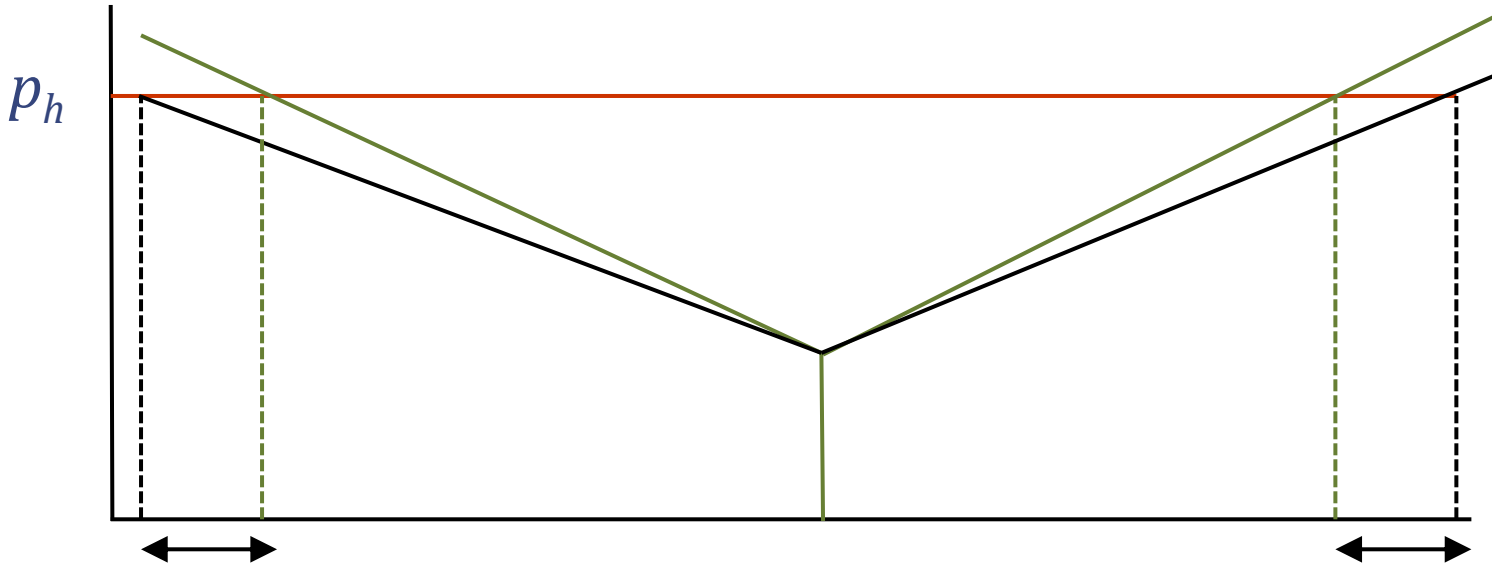
4. Hotelling's model of spatial competition

- Market area
  - When external economies of scale become important



4. Hotelling's model of spatial competition

- **Market area**
  - **When there are economies of scale in transport**



5. Central place theory

- Walter Christaller and August Lösch

- Central place theory
  - Explains differences in city sizes and functions within a region or country
  - How many cities?
  - Why are some cities bigger than others?

- Assumes that each sector has a market area for consumer goods

5. Central place theory

- Intuition
  - Because of economies of scale vary by sector, cities differ in scale and scope
  - There is a hierarchy in cities

- E.g. demand for pizzas vs. demand for opera

- Large cities are more diverse!

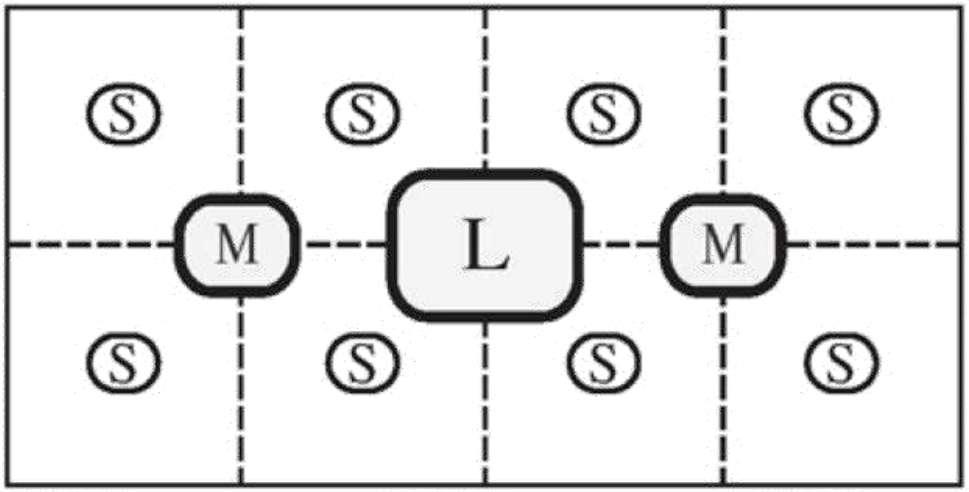
5. Central place theory

- **Model setup**
  - Model of firm location based on access to consumers
    → Ignores production costs
  - Uniform population density
  - No shopping externalities
    → No shop chaining
  - Ubiquitous inputs
    → Production costs uniform across locations
  - Uniform demand for each product

5. Central place theory

- **Example: let's assume a two-dimensional plain**

  Q Where would the jewelry be located

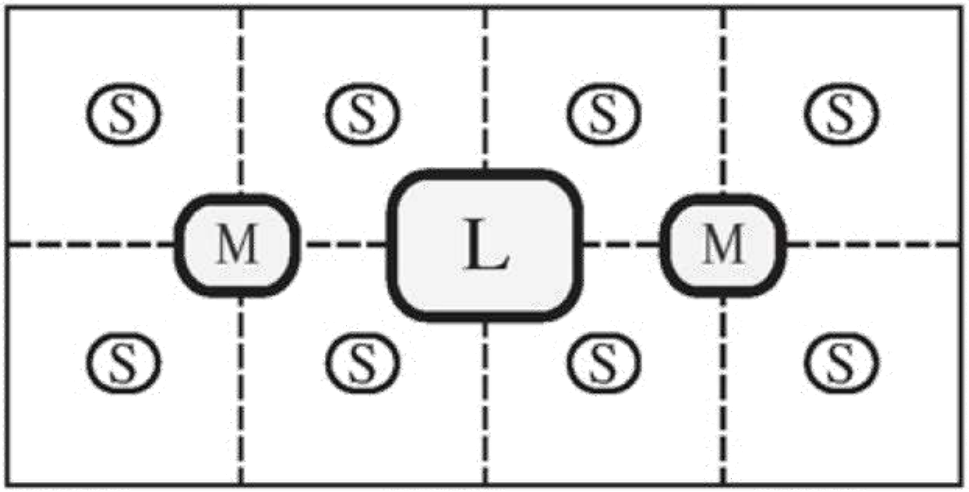


City L	M Cities	S Cities
1 Jeweler	1 Book store	1 Pizzeria
2 Book stores	2 Pizzerias	
4 Pizzerias		

There are 11 cities in the region, one large city (L), two medium-sized cities (M), and eight small cities (S). The larger the city, the greater variety of goods sold.

5. Central place theory

- **Example: let's assume a two-dimensional plain**



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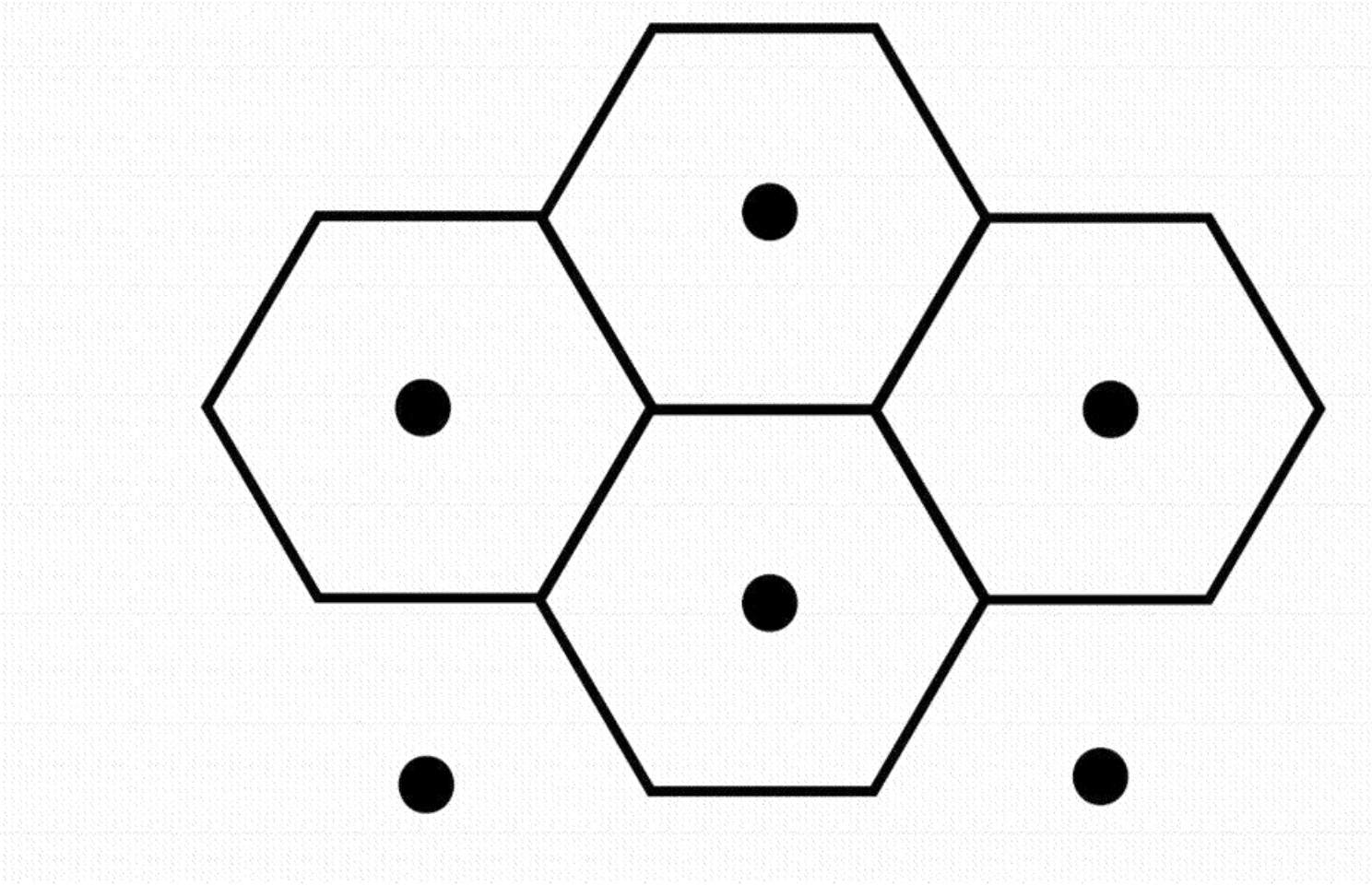
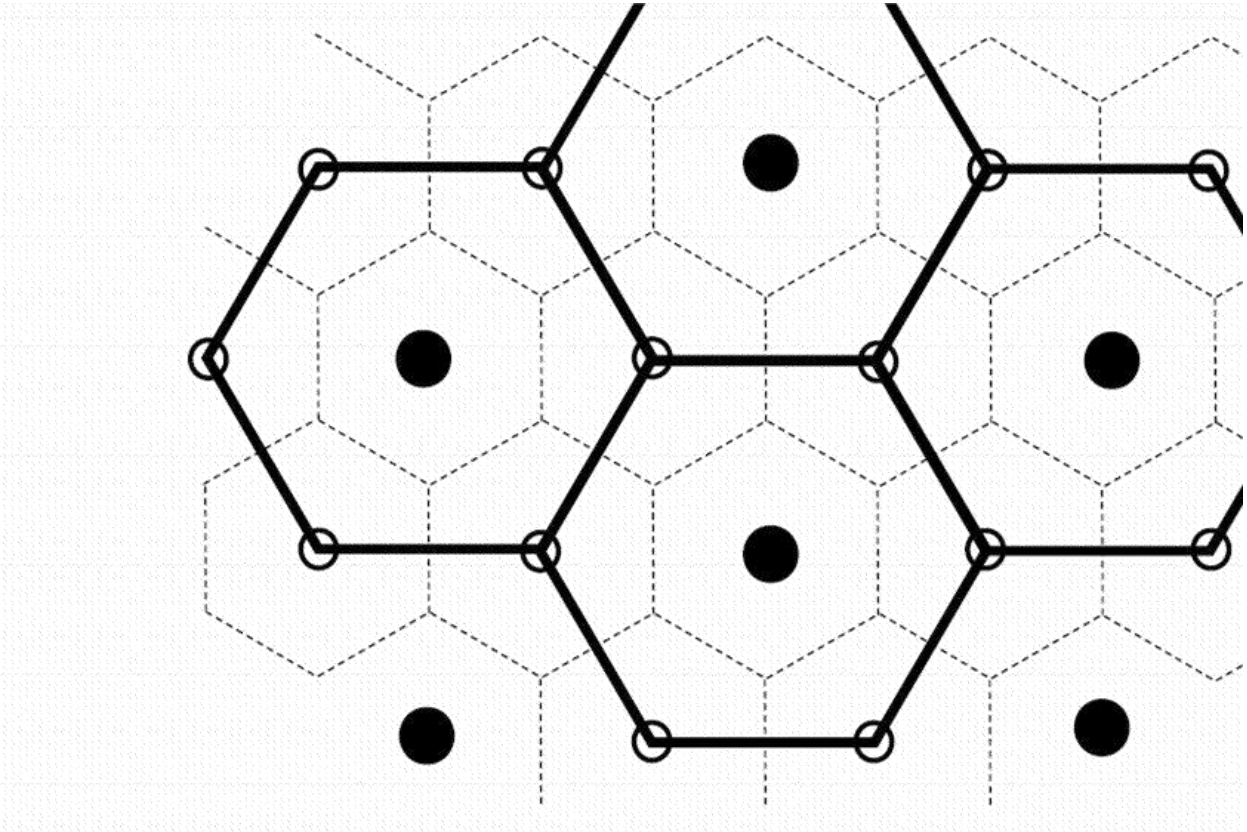
5. Central place theory

- **Market areas**



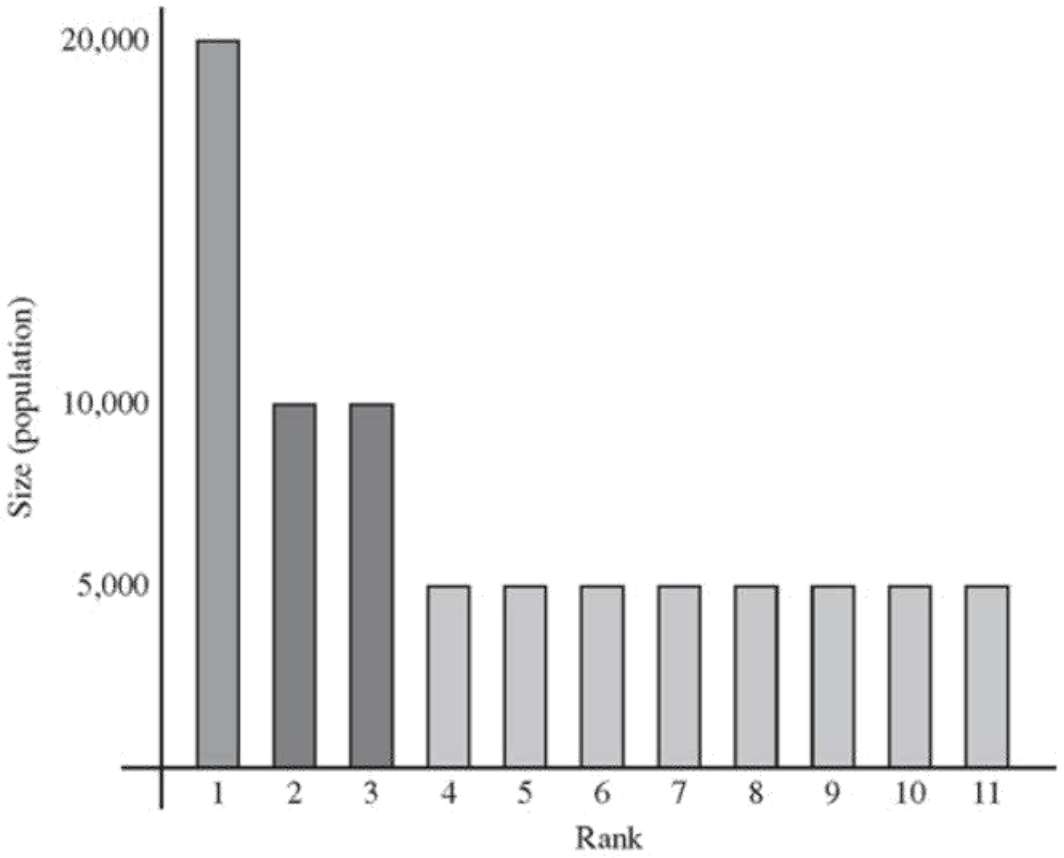
5. Central place theory

- **Market areas**
  - **With a second level, this becomes:**



5. Central place theory

- **City size distribution implied by central place theory**



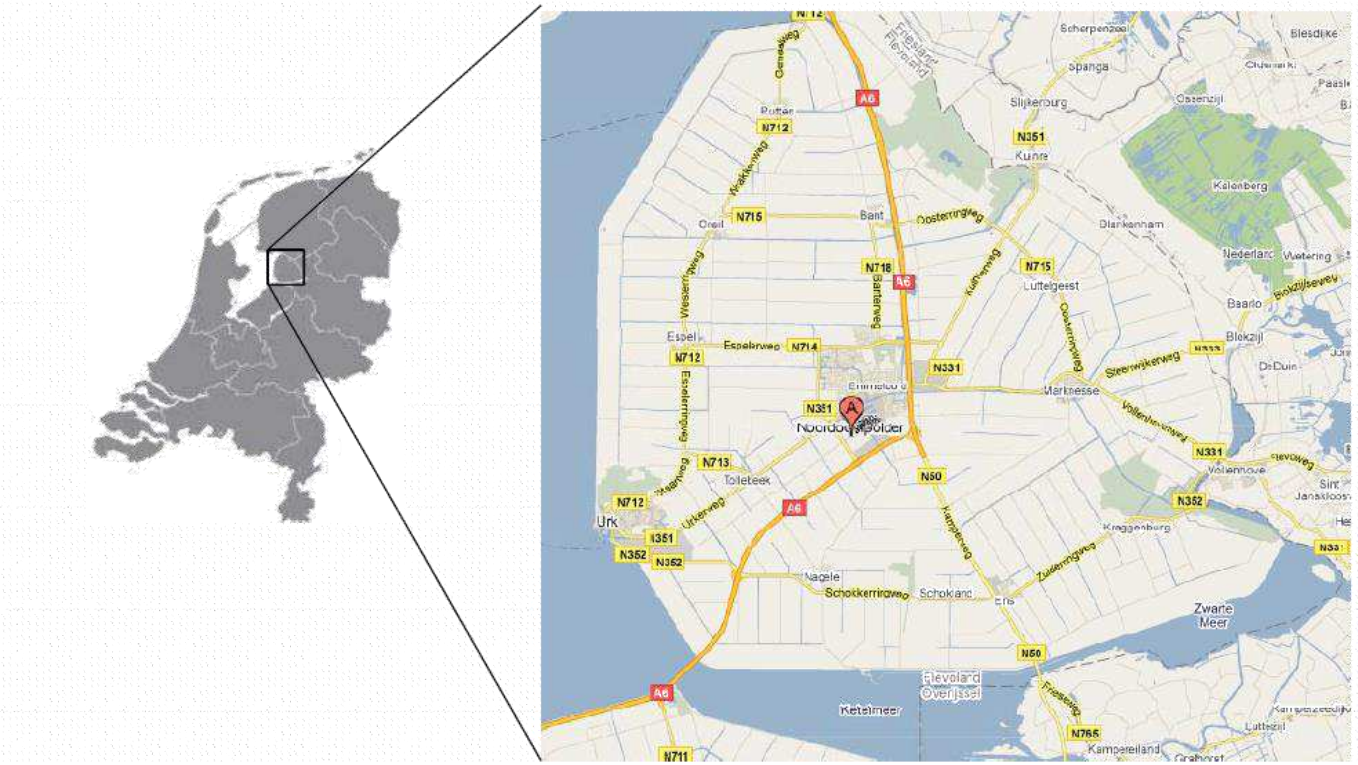
The simple central place model generates one large city (L) with a population of 20,000, two medium-sized cities, each with a population of 10,000, and eight small cities, each with a population of 5,000.

5. Central place theory

- **Insights into urban hierarchy**
  - Diversity in size and scope from differences in scale economies relative to per-capita demand
  - Small number of large cities and large number of small cities
  - Larger cities offer more functions
  - Larger cities have more establishments per function
  - Consumers travel to larger cities, but not to smaller cities or cities of the same size

5. Central place theory

- **Central place theory in the Netherlands**
  - **In an area of reclaimed land**



5. Central place theory

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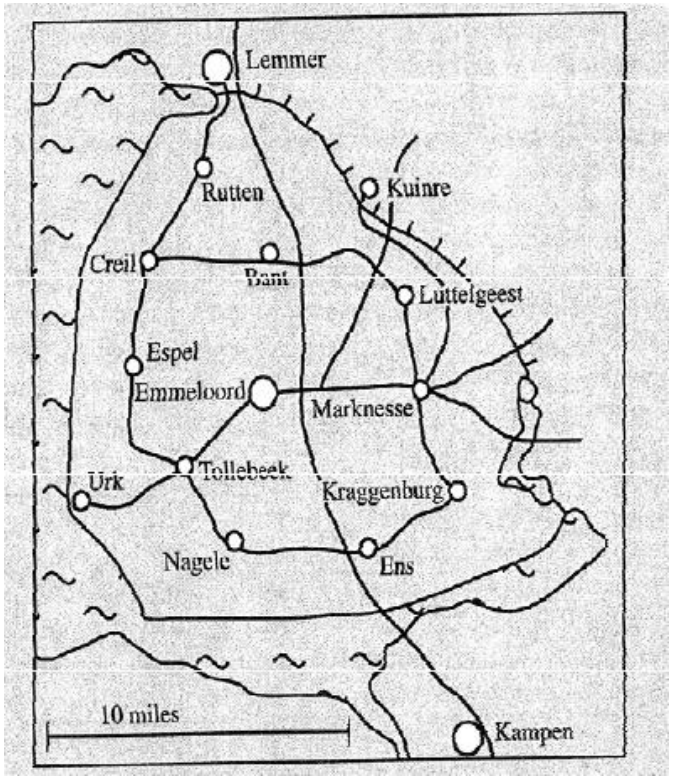


	Start	Planned p
Emmeloord	1946	10,000
Marknesse	1946	2,000
Ens	1948	2,000
Kraggenburg	1948	2,000
Luttelgeest	1950	2,000
Bant	1951	2,000
Rutten	1952	2,000
Creil	1953	2,000
Nagele	1954	2,000
Espel	1956	2,000
Tollebeek	1956	2,000

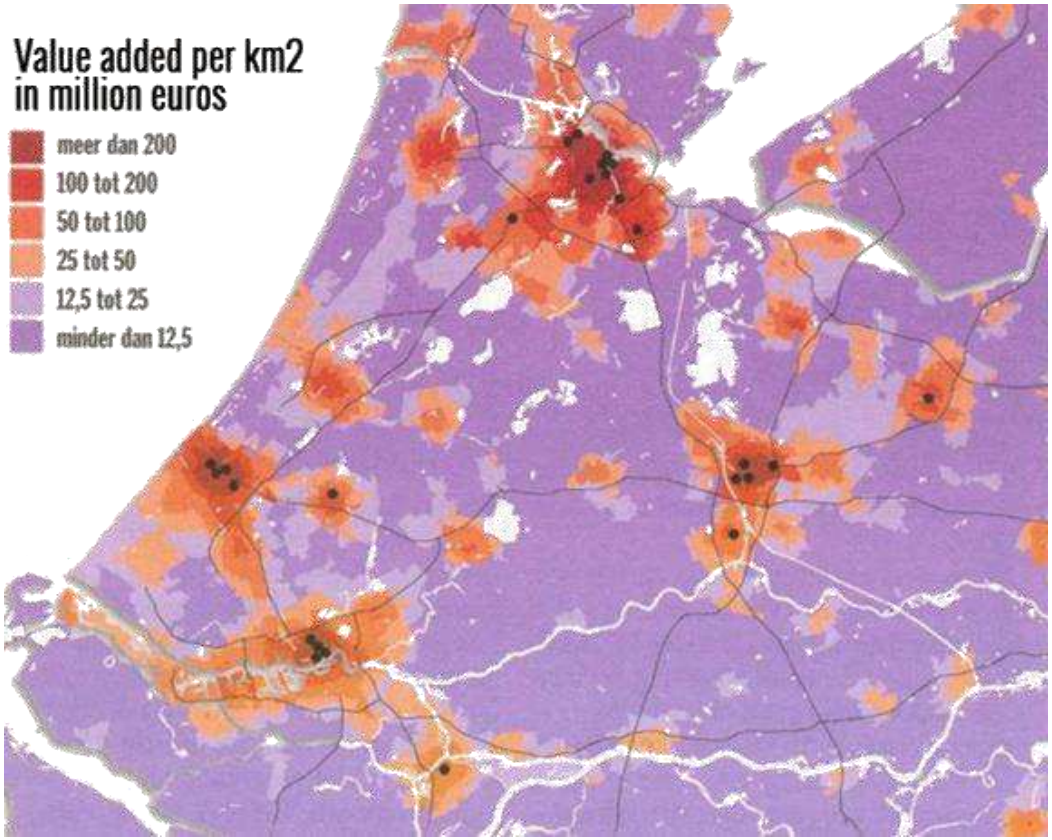
Source: "Dorpen in de IJsselmeerpolders," Rijks

5. Central place theory

- **Limits of central place theory**
  - **Focus on location choice of firms based on consumer locations**
    - **→ Both are endogenous**
  - **Ignores agglomeration economies**

6. Internal vs. external returns to scale

- It seems that firms are much more productive in cities



6. Internal vs. external returns to scale

- **Firms often locate in cities**
  - **Because a firm enjoys benefits that compensate for the higher cost**

- **Benefits**
  - **Market share effect** *(Hotelling!)*
  - **Agglomeration economies**
  - **Other reasons**

6. Internal vs. external returns to scale

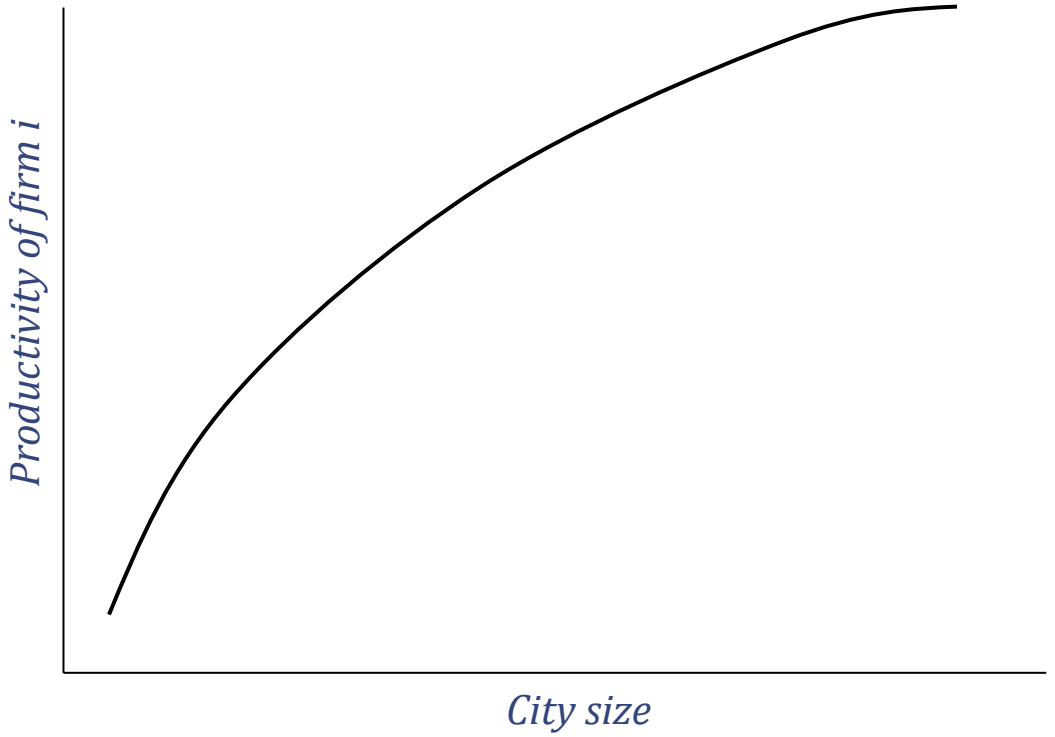
- *Returns to scale* is a central concept in economics

- A firm may experience *internal* returns to scale and therefore concentrate its facilities
  - ℚ Why may firms experience internal returns to scale?

- A firm may also enjoy *external* returns to scale
  - ℚ What would that be?

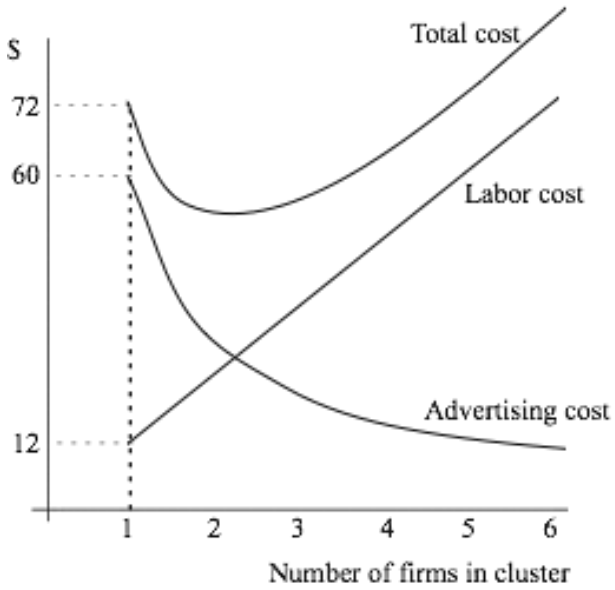
6. Internal vs. external returns to scale

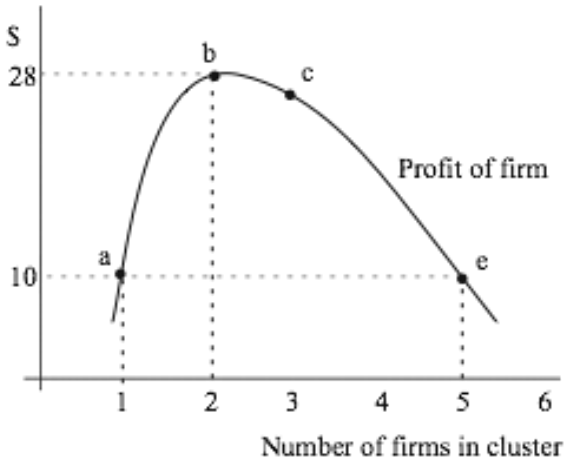
- *External* returns to scale
  - Firms benefit from each others' presence
  - Agglomeration economies!



6. Internal vs. external returns to scale

- **Agglomeration economies**
  - ℚ **Why may advertising costs decrease in the number of firms why labour costs increase in the number of firms per cluster?**





6. Internal vs. external returns to scale

Agglomeration economies

- **Localisation economies**
  - Agglomeration economies that are relevant only *within* an industry

- **Urbanisation economies**
  - Agglomeration economies that are relevant between industries

6. Internal vs. external returns to scale

Localisation economies

- Examples of clusters in the Netherlands

Q Can you think of other examples in the world?

Metal and Electronic Industry

ICT

Culture & Other services

6. Internal vs. external returns to scale

Localisation economies

- Examples of clusters
  - Silicon Valley, CA, USA: *Computer industry*
  - Paris, France: *Fashion*
  - Toulouse, France: *Aerospace industry*
  - Cambridge, UK: *Biotechnology*
  - Antwerp, Belgium: *Diamond industry*
  - …

6. Internal vs. external returns to scale

Urbanisation economies

- A city is much larger than a specific cluster
- Firms may benefit from firms in other industries
  - e.g. legal services, accountants
- Firms may benefit from city size in general
  - e.g. shops, theatres

7. Sources of agglomeration economies

- **What are the sources of agglomeration economies exactly?**
  - ℚ **Can you think of any *reasons* why firms would cluster?**

7. Sources of agglomeration economies

- Marshall (1920) already discusses agglomeration economies

- He defined three main sources
  1. Input- and output sharing *(sharing)*
  2. Labour market pooling *(matching)*
  3. Knowledge spillovers *(learning)*

7. Sources of agglomeration economies

1. Input/output sharing

- Lower transportation costs of *goods*

- *Input sharing:* A cluster will attract input suppliers
  - Lower input prices due to competition
- *Output sharing:* More potential customers

Q Is this source as important today as it was in the past?

Q For what sector is output sharing still very important?

7. Sources of agglomeration economies

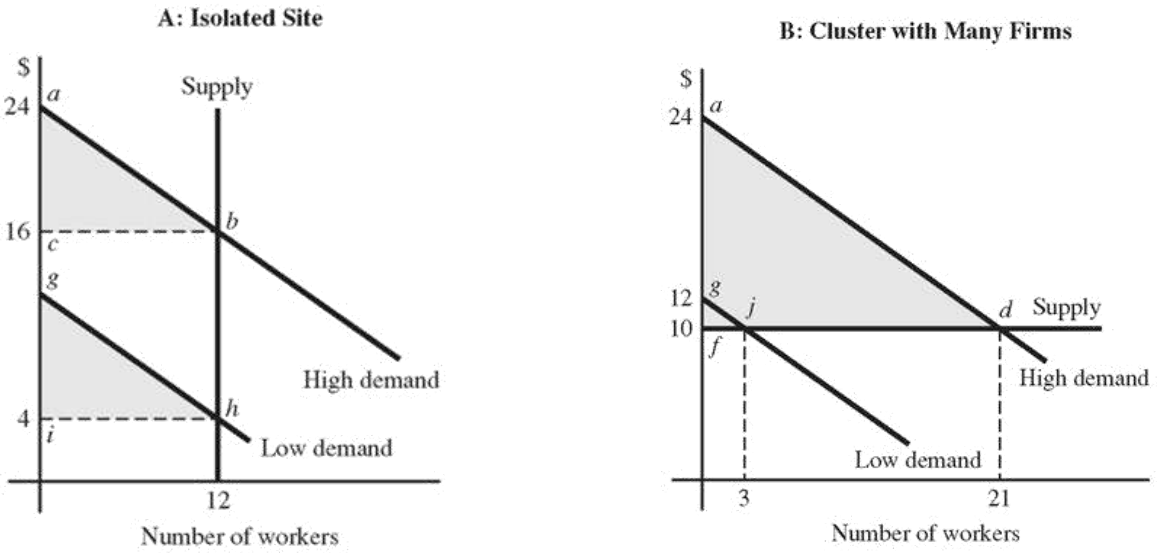
2. Labour market pooling

- Lower transportation costs of *people*

- Varying demand for labour
- Varying supply of labour
- Easier to find the ideal worker

7. Sources of agglomeration economies

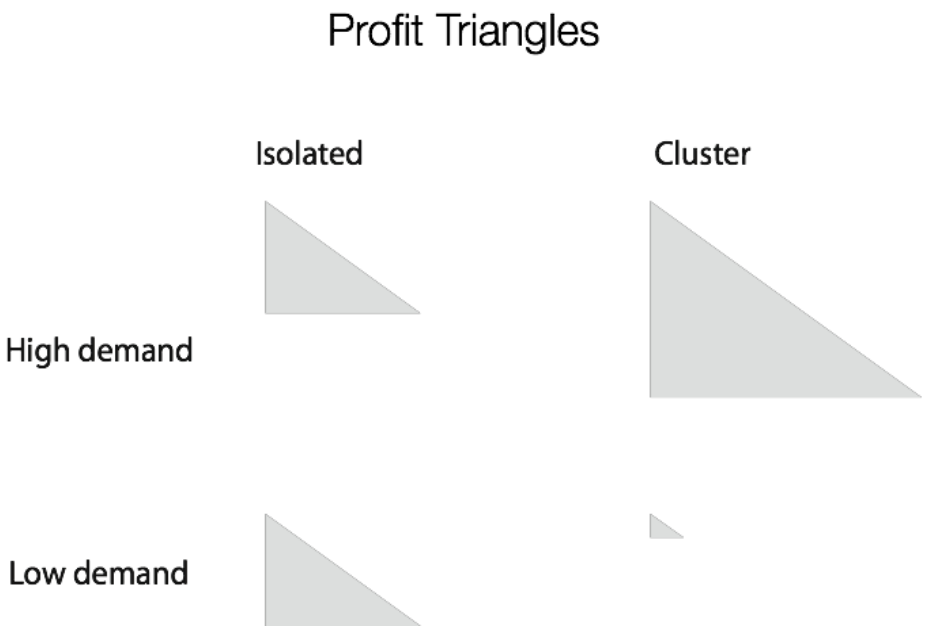
2. Labour market pooling



- **Labor demand:** $marginal\ benefit\ =\ MRP$
- **Profit from an individual worker =** $MRP\ -\ wage$
- **Profit from workforce:** ***From marginal to total product of labour and surplus***

7. Sources of agglomeration economies

2. Labour market pooling



7. Sources of agglomeration economies

2. Labour market pooling

- Easier to find ideal workers
  - Highly-educated people in Amsterdam
  - Moviestars in Hollywood
  - Study model of Helsley and Strange (1990), pp. 54

7. Sources of agglomeration economies

3. Knowledge spillovers

- Lower transportation costs of *ideas*
- Formal and informal exchange of information
  - Labour mobility between firms
  - Pubs, etc.

- Example: Silicon Valley
  - Specialised firms
  - Cooperation with nearby other firms
    → Leading to new ideas

7. Sources of agglomeration economies

Other reasons for clustering

- Natural advantages
  - Q Examples…

7. Sources of agglomeration economies

Other reasons for clustering

- Natural advantages
  - Natural harbours
  - Mines
  - Favourable climate
  - …
- Local policies
  - Place-based subsidies
  - Tax incentives
    - → E.g. Offshore insurance in Bermuda
  - Institutions!

8. Empirical evidence

𝔸 *Combes et al. (2010)*

- **If workers are more productive in cities, wages should be higher**

- **Wage regression**

$$\log(wage_{it}) = \alpha + \beta \times \log(density_{it}) + \gamma \times controls + \theta_t + \epsilon_{it}$$

- **Problem: sorting**
  - **More able individuals may sort themselves into urban areas (e.g. due to amenities)**
  - **So, adjust specification:**

$$\log(wage_{it}) = \alpha + \beta \times \log(density_{it}) + \gamma \times controls + \eta_i + \theta_t + \epsilon_{it}$$

- **By including 'individual fixed effects', one controls for all variation caused by individual characteristics**

8. Empirical evidence

- *Combes et al. (2010)*

- **Data from France on >2.5 million workers**

- **Results**
  - **Doubling of density increases wages with about 3%**
  - **Large part of spatial variation in wages is caused by sorting of individuals**
    → **More able individuals indeed sort themselves into urban areas**
  - **Locational 'endowments' seem to be less important**

8. Empirical evidence

- *Koster et al. (2014)*

- **If firms are more productive, office rents should be higher**

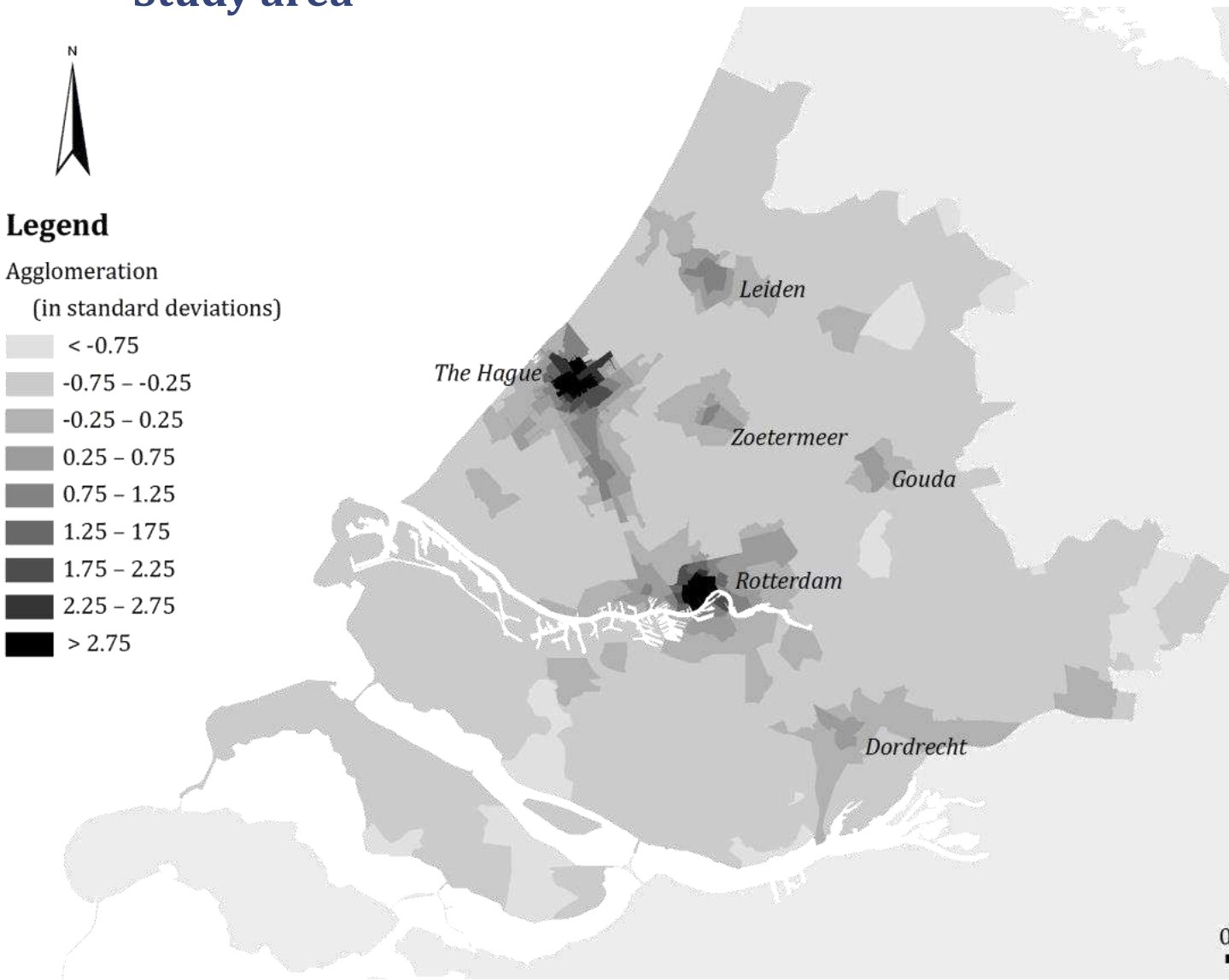
- **Data from the Netherlands on >2.5 thousand rental office transactions**

- **Equation to be estimated:**

$$\log(rent_{it}) = \alpha + \beta \times \log(density_{it}) + \gamma \times controls + \theta_t + \epsilon_{it}$$

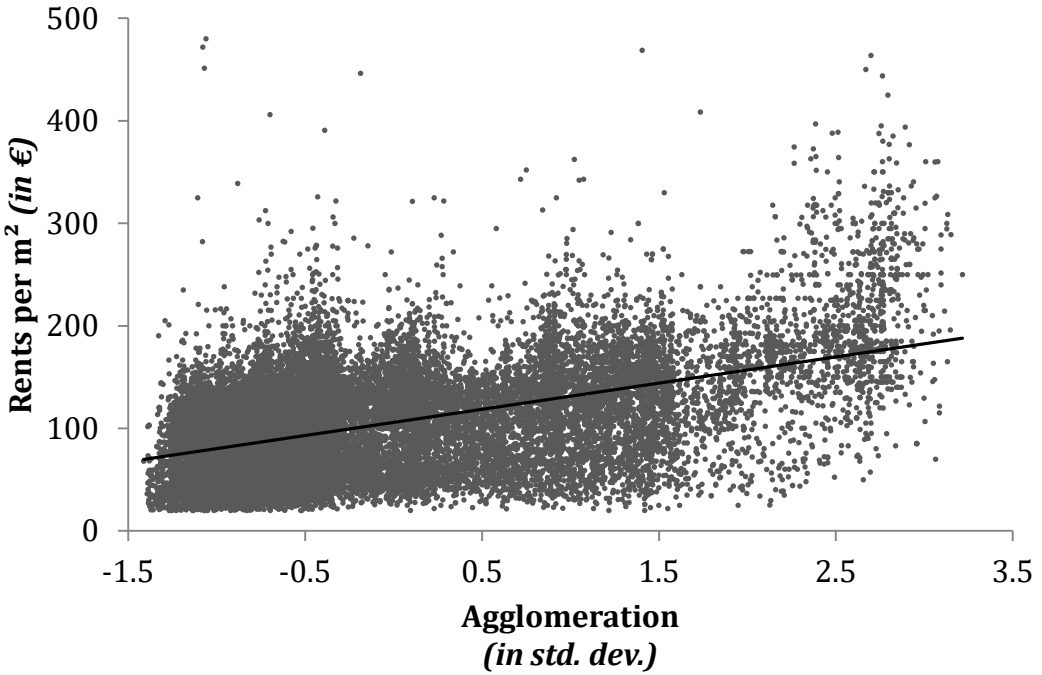
8. Empirical evidence

- **Study area**



8. Empirical evidence

- If firms are more productive, office rents should be higher
  - At least there is a positive correlation
  - ℚ Why is this not interpretable as a *causal* effect of agglomeration economies?



SOURCE: Koster (2013)

8. Empirical evidence

- **Regression models where we control for other factors**

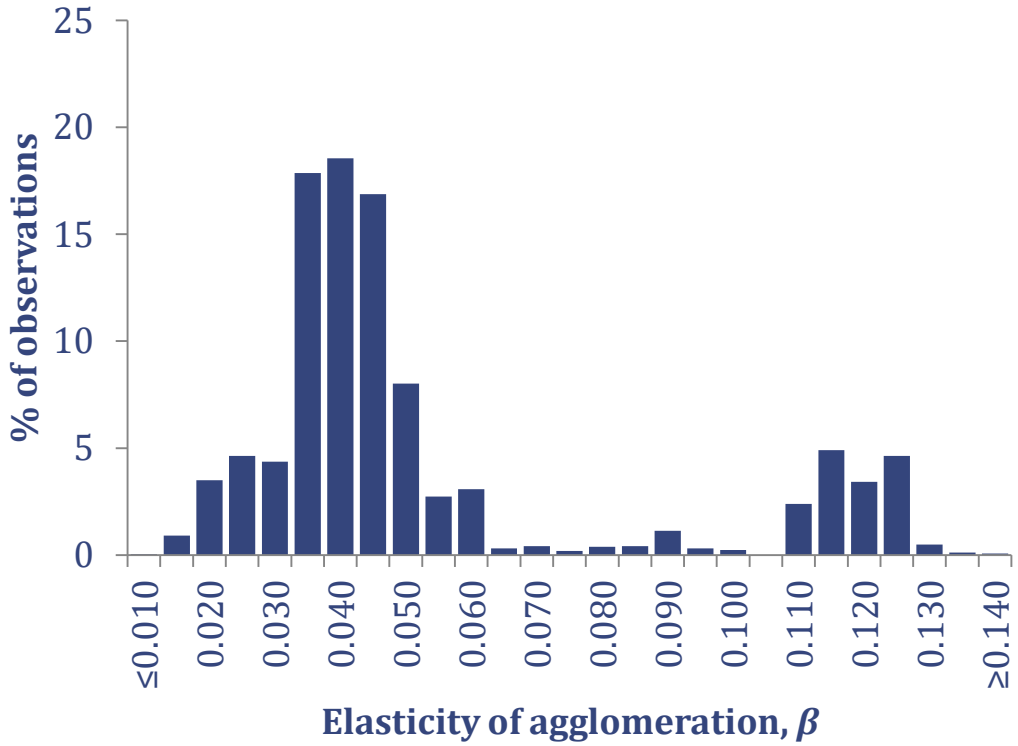
	OLS	2SLS
Density *(log)*	0.082*	0.051*
Controls (96)	Yes	Yes
n	2,631	2,631

Note: Dependent variable is rent *(log)*. The asterisk indicates that the coefficient is statistically significant at the 1% level.

Q How to interpret the estimated coefficients?

8. Empirical evidence

- **But: effects are different between sectors**
  - **Retail firms are relatively the most productive in urban areas**



8. Empirical evidence

Other empirical evidence

- *Ellison et al. (2010)*
  - **Input sharing > labour market pooling > knowledge spillovers**
- *Rosenthal and Strange (2002)*
  - **Localisation economies are important**
  - **Decay within a mile!**
- *Arzaghi and Henderson (2008)*
  - **Important for advertising industry**
  - **Decay in half a mile**

9. Summary

Location theory

- Principle of median location

- We discussed three main models
  - Weber's location choice model
  - Hotelling's spatial competition model
  - Christaller's central place theory

9. Summary

Agglomeration economies

- Internal vs. external returns to scale

- Sources of agglomeration economies
  1. Input- and output sharing *(sharing)*
  2. Labour market pooling *(matching)*
  3. Knowledge spillovers *(learning)*

- Other reasons for clustering
  - Natural advantages
  - Local policies

- Substantial empirical evidence for presence of agglomeration economies

9. Summary

Questions?

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See also URBANECONOMICS.NL

- **See *www.urbaneconomics.nl/coursematerial* for lecture sheets and links to papers**