Socio-Economic Aspects of Urban Development

Unit 12: Business Agglomeration and Firm Clusters

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Overview of Unit 12

- How do cities attract firms? The location decision
  - The role of business taxation and tax competition between municipalities
- Agglomeration effects and business clusters
  - What are agglomeration effects?
  - Types of agglomeration effects
  - Attempts to measure and quantify them
  - Horizontal and vertical agglomeration
- Business clusters in Leipzig
  - Spatial distribution of firms from different sectors
  - QGIS exercise: Business clusters with Open Street Map firm data

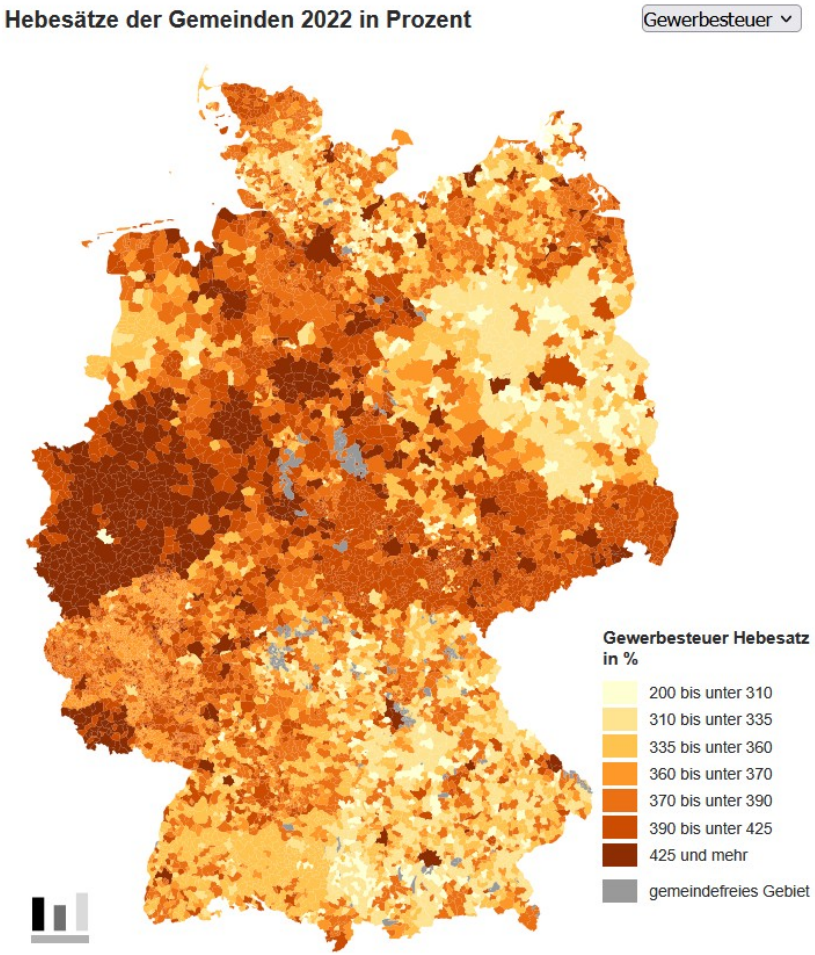
How can Cities Attract Firms?

- What are firms looking for when deciding on their location?
  - Company taxation
    - ★ In Germany, *Gewerbesteuer* (license tax for companies) is the only tax entirely determined, raised and spent at the municipal level.
  - Affordable rents for business space
    - ★ This varies with the industry: Compare an IT start-up with a huge manufacturing plant
  - Infrastructure: Good transportation links
    - ★ To be easily reachable for suppliers, clients, workers
    - ★ But infrastructure also includes communication infrastructure
  - Highly-educated and specialized workforce
    - ★ What is the local wage level and the skills distribution?
  - Business-friendly political environment
  - Presence of other firms from the same industry

How Important are Low Business Taxes?

In Germany, *Gewerbesteuer* that firms have to pay to their municipalities is calculated as

$$\text{Profit} \cdot 3.5\% \cdot \text{Hebesatz} \tag{1}$$



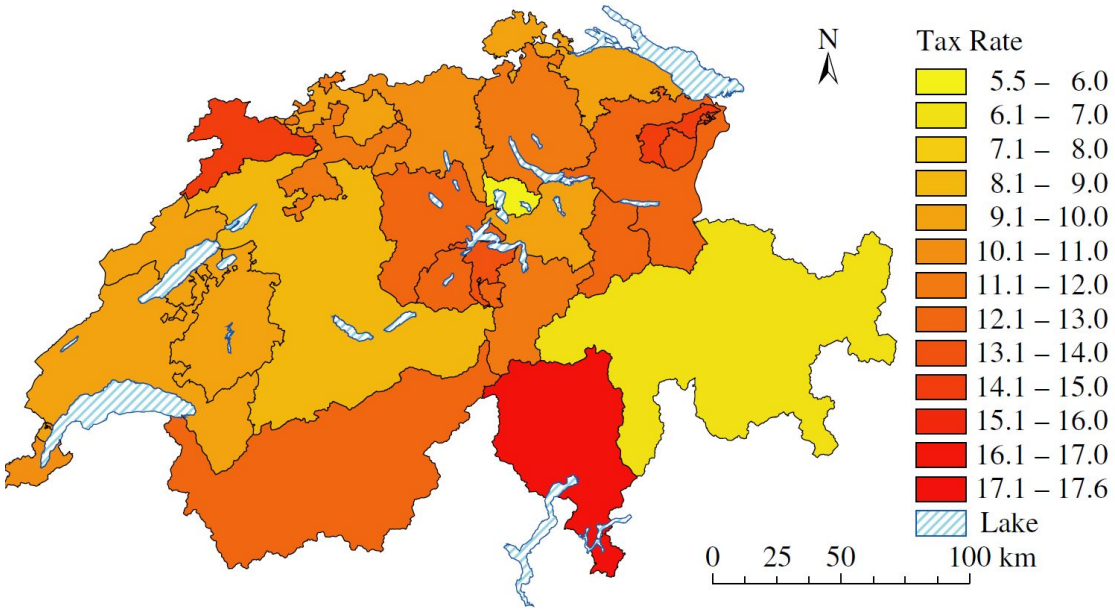
How Important are Low Business Taxes?

- In 2010, Deutsche Börse moved its headquarters from Frankfurt am Main to neighboring Eschborn, into the new building *The Cube*
- In Eschborn, *Hebesatz* was only 280%, compared to 460% in Frankfurt
- Note that Eschborn is just a 15-minute public transport ride from Frankfurt and belongs to the same labor market region. Would low taxes also have enticed them to move to a rural region further away?



Brülhart et al. (2012): Tax Competition and Clusters

- To understand the importance of taxes in comparison to other factors, Brülhart, Jametti und Schmidheiny (2012) work with Swiss data on company creation.
- They regress the number of new firms per municipality and sector on many different variables, among them company tax. Cantons and Municipalities have almost complete autonomy over the company tax rate, resulting in a large spatial variation of tax rates.



Brülhart et al. (2012): Tax Competition and Clusters

- Data on every newly created firm from the Swiss Statistical Office (1999-2002)
  - Categorized by municipality and economic sector: 26,333 new firms
- Also survey data on all existing firms in order to measure firm clusters
  - They compute the Ellison-Glaeser Index of spatial concentration of firms
- Location specific variables (apart from taxes):
  - Local wages
  - Population
  - Public expenditure (as a proxy for education, transport etc)
  - Distance to highways
  - Market potential (distance-weighted income)

Brülhart et al. (2012): Tax Competition and Clusters

Watches and clock manufacturing (upper map) is more spatially concentrated than software development and consulting (lower map)

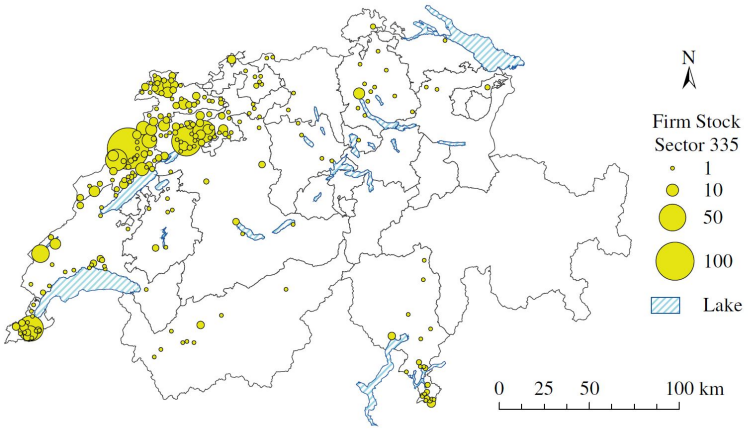
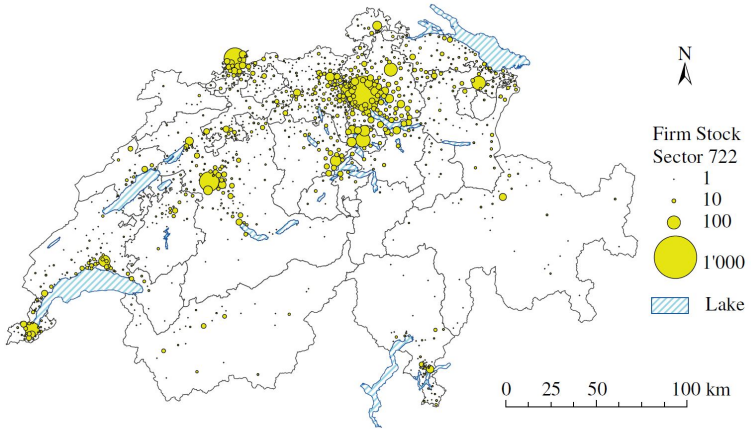


Fig. 4. *Watches and Clocks, Distribution of Firms in* 1998



Brülhart et al. (2012): Tax Competition and Clusters

$$\pi_{fij} = U_{ij} + \varepsilon_{fij} = \alpha_1 T_j + \alpha_2 A_i + \alpha_3 T_j A_i + \boldsymbol{\beta}' \boldsymbol{x}_{ij} + \varepsilon_{fij}.$$

- A firm belonging to sector i has decided to set up a new plant f and now considers which location j to choose. Regress the new plants on:
  - Taxes T_j are expected to enter with a negative sign
  - Agglomeration effects A_i (business concentration in this sector) are expected to enter with a positive sign
  - Interaction effect $T_j \cdot A_i$: A positive coefficient means that agglomeration effects (partially) counteract the negative effect of taxes. The negative impact of taxes on firms' location decision can be reduced thanks to agglomeration effects. In other words: **Firms are willing to bear higher taxes in order to benefit from a firm cluster** ($\Longrightarrow$ Opportunity for higher taxation by cities)
  - All the other local variables are control variables (X_{ij})

Brülhart et al. (2012): Tax Competition and Clusters

Different econometric regressions (OLS, 2 Stage Least Squares, Poisson): $\Longrightarrow$ All agree on the positive interaction effect between taxes and agglomeration effects (second row).

	Dep. var. = number of new firms per municipality and sector		
	OLS	2SLS	Poisson
	(1)	(2)	(3)
Tax	−0.043**	−0.011	−0.031**
	(0.017)	(0.018)	(0.015)
Tax × [EG index − mean(EG index)]	0.713*	5.454*	1.735**
	(0.401)	(2.849)	(0.817)
Wage	−0.128**	−0.313***	−0.478***
	(0.064)	(0.119)	(0.066)
Wage × [EG index − mean(EG index)]	0.690	0.424	1.949
	(1.559)	(5.279)	(2.652)
Property price	0.181*	−1.247*	0.351***
	(0.106)	(0.688)	(0.081)
Property price × [EG index − mean(EG index)]	−0.275	28.752*	17.174***
	(4.373)	(14.872)	(3.719)
Stock of firms	0.179***	0.178***	0.0001**
	(0.027)	(0.027)	(0.0001)
Income tax rate	−0.108***	−0.652***	−0.199***
	(0.025)	(0.244)	(0.021)
Public expenditure	0.003	0.037	−0.017***
	(0.008)	(0.038)	(0.006)
Market potential	0.118***	0.230***	0.281***
	(0.041)	(0.072)	(0.032)
Distance to highway	−0.008*	0.007	−0.008***
	(0.004)	(0.006)	(0.003)
Assisted municipalities	0.020	0.039	0.044
	(0.049)	(0.061)	(0.038)
log population	−0.164	−0.018	1.021***
	(0.271)	(0.276)	(0.015)
Sector fixed effects	yes	yes	yes
Municipality fixed effects	no	no	no
R^2	0.69	0.69	

What are Agglomeration Effects Actually?

- Agglomeration effects are driven by
  - **Density** (firms clustering close together)
  - **Size** (a large number of firms)
- In many clusters of firms, density and size typically reinforce each other. They lead to **agglomeration effects** by gathering many firms and workers in one place.
- **Classification of Agglomeration Effects** by Marshall (1920), see also Duranton und Puga (2004):
  1. **Sharing**: Intermediate products can be acquired more cheaply with more companies, thereby producing output more efficiently
  2. **Matching** through Labor Market Pooling: The larger supply and demand pool of labor leads to a better match between the needs of companies and the (specialized) skills of workers
  3. **Learning**: Thanks to many interactions, workers can learn from each other and firms can learn from their competitors (**Technology Spillovers, Knowledge Spillovers**)

Types of Agglomeration Effects

Duranton and Puga (2004) discuss the micro-foundations of these individual agglomeration effects:

- 1. **Sharing**
  - Sharing of indivisible goods and facilities (infrastructure, trading places, large facilities)
  - Shared profiting from diversity ('gains of variety' through differentiated intermediate products ensures increasing economies of scale)
  - Joint profiting from individual specialization (focus on specialized tasks and products at the individual level)
  - Joint sharing of risk through larger markets

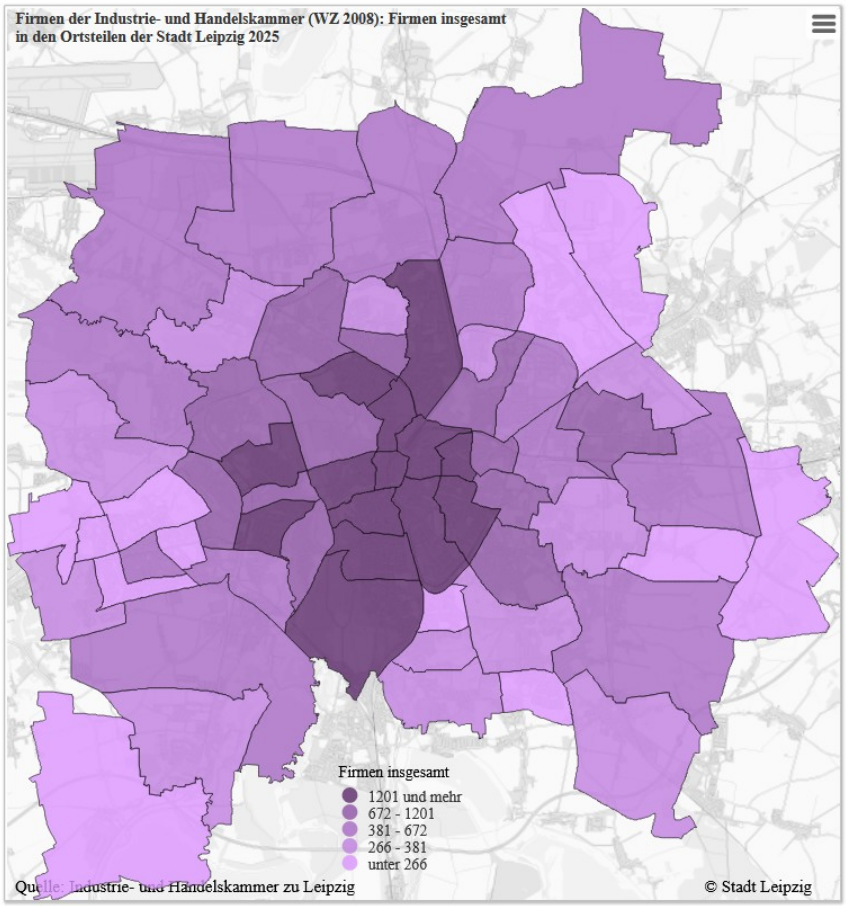
Types of Agglomeration Effects

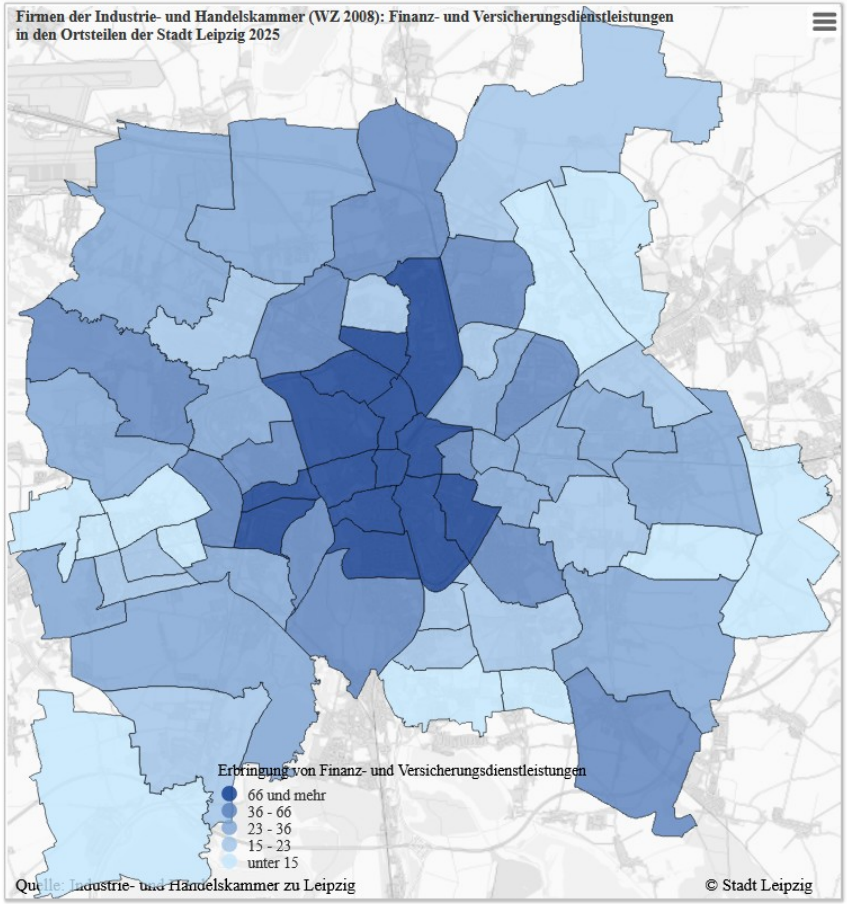
- 2. **Matching**
  - Better fit of workers to advertised jobs due to the larger supply/demand pool
  - Greater likelihood of contracting due to the larger number of individuals and firms
  - Fewer hold-up problems (less extortion/exploitation due to lack of alternatives)
    - ★ Workers can more easily find another job, firms can more easily find another person to fill the position
- 3. **Learning**
  - Knowledge generation and accumulation through the diversified urban environment
  - Knowledge diffusion thank to interactions with many individuals

Spatial Distribution of Firms in Leipzig

The number of firms per district in Leipzig (left) and only firms in banking, finance and insurance (right)

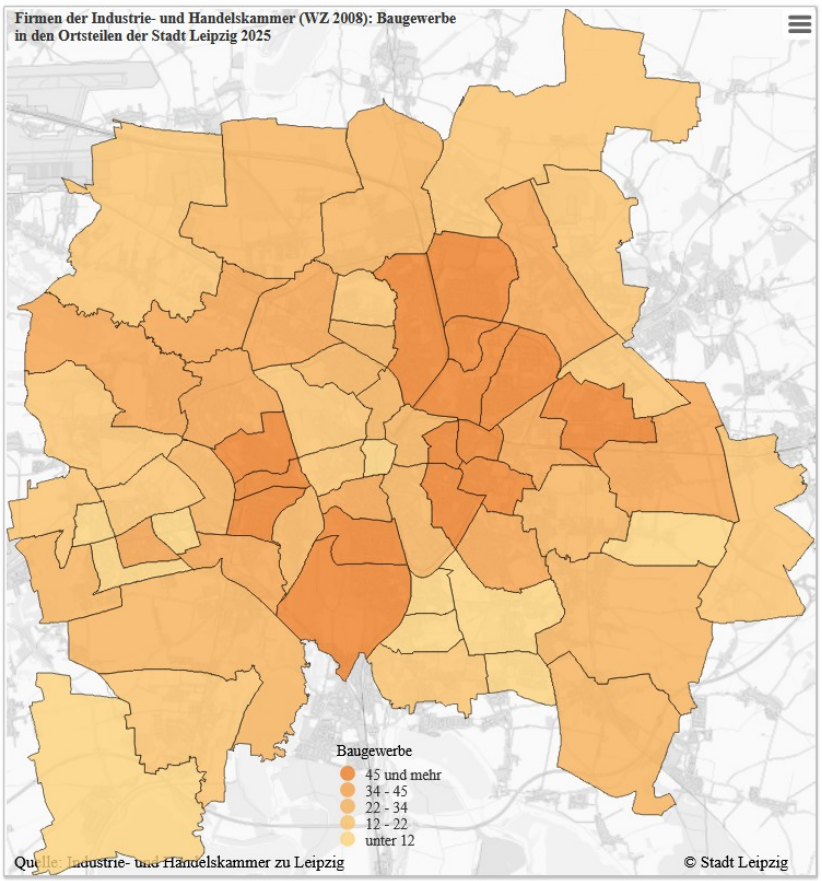
Data from 2025, sectoral classification according to *Industrie- und Handelskammer WZ 2008*

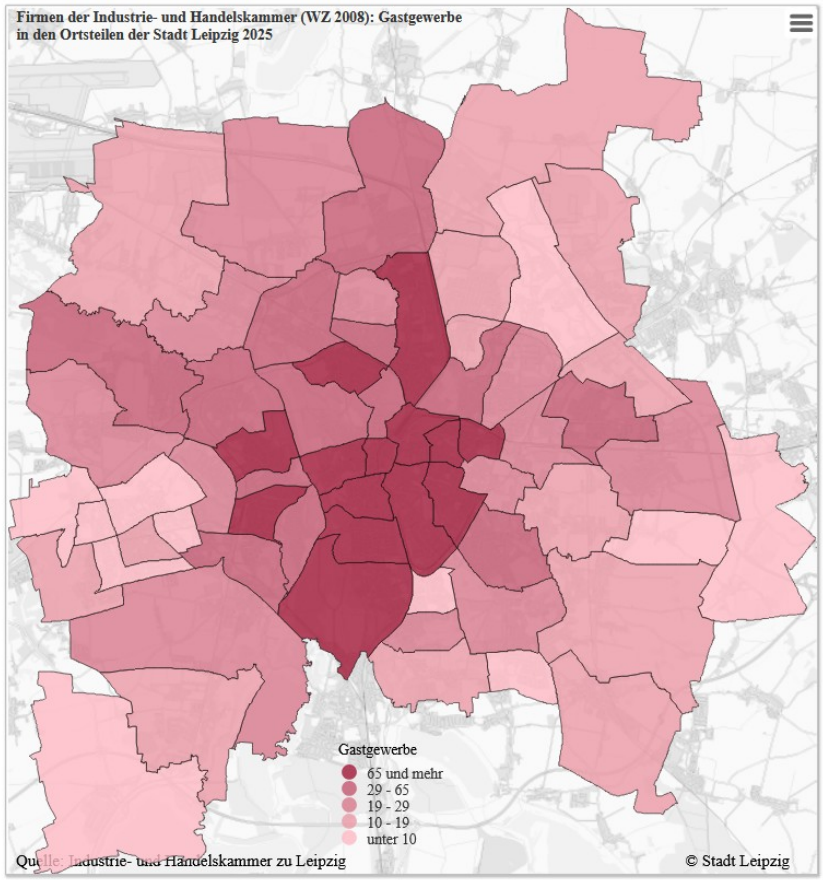




Spatial Distribution Firms in Leipzig

The spatial distribution of firms varies according to their sector:
Compare the location of firms from the construction industry (left) with those from the hospitality sector (right)



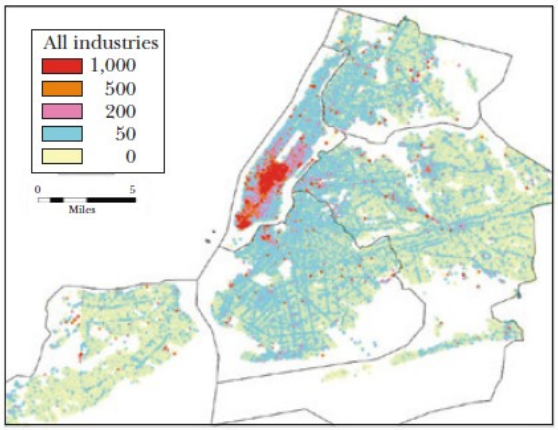


Agglomeration Effects: Rosenthal und Strange (2020)

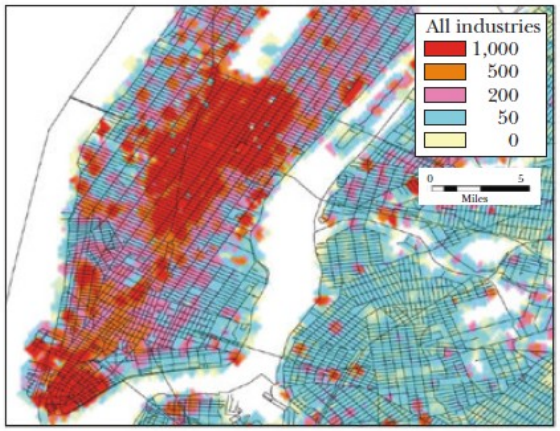
Employment within 0.05 Miles in the Five Boroughs of New York City

(all values are smoothed out to 0.1 miles with inverse exponential distance weighting)

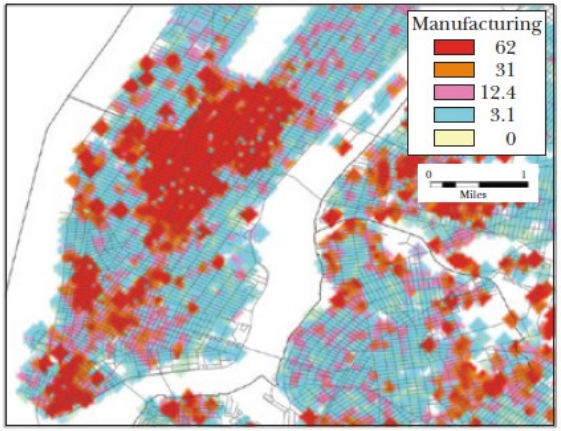
A: All industries



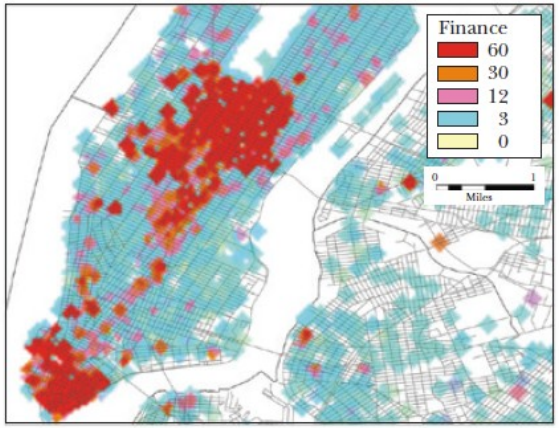
B: All industries



C: Manufacturing



D: Finance



Agglomeration Effects: Rosenthal und Strange (2020)

- In their article *'How Close Is Close? The Spatial Reach of Agglomeration Economies'*, Rosenthal and Strange (2020) show that agglomeration effects operate at different spatial levels. Rule of thumb: the closer, the stronger!
  - Within an **urban area**, companies in certain industries cluster in certain neighborhoods (New York City -> Manhattan).
  - Within these **neighborhoods**, there is often another cluster effect (e.g., the financial industry within Manhattan is located almost exclusively in Midtown south of Central Park and at the southern tip of Manhattan).
  - There are even indications of agglomeration effects within blocks and individual **buildings**: higher employment density of companies when there are other companies of the same industry in the office building.

Vertical Sorting and Agglomeration: Liu et al. (2018)

- The spatial distribution of firms and geographical proximity is typically based on horizontal distance. In their article *'The Vertical City'*, Liu, Rosenthal and Strange (2018) look at the vertical dimension: Firms on top of each other in high office buildings
- They use data from a commercial real estate firm on floor-specific office rent in nearly 2000 buildings in 18 U.S. cities
- Regressing rent on floors and company-specific characteristics, they find:
  - Rent is a non-monotonous function of the floor, highest on the ground floor, then decreasing and finally increasing again with the highest floors
  - Similar to residential buildings, **access and amenities** are traded off: Access matters mostly for retail firms (and generally those with many clients), while an important amenity is the view from the top (prestige, signaling function to employees, clients and competitors).

Vertical Sorting and Agglomeration: Liu et al. (2018)

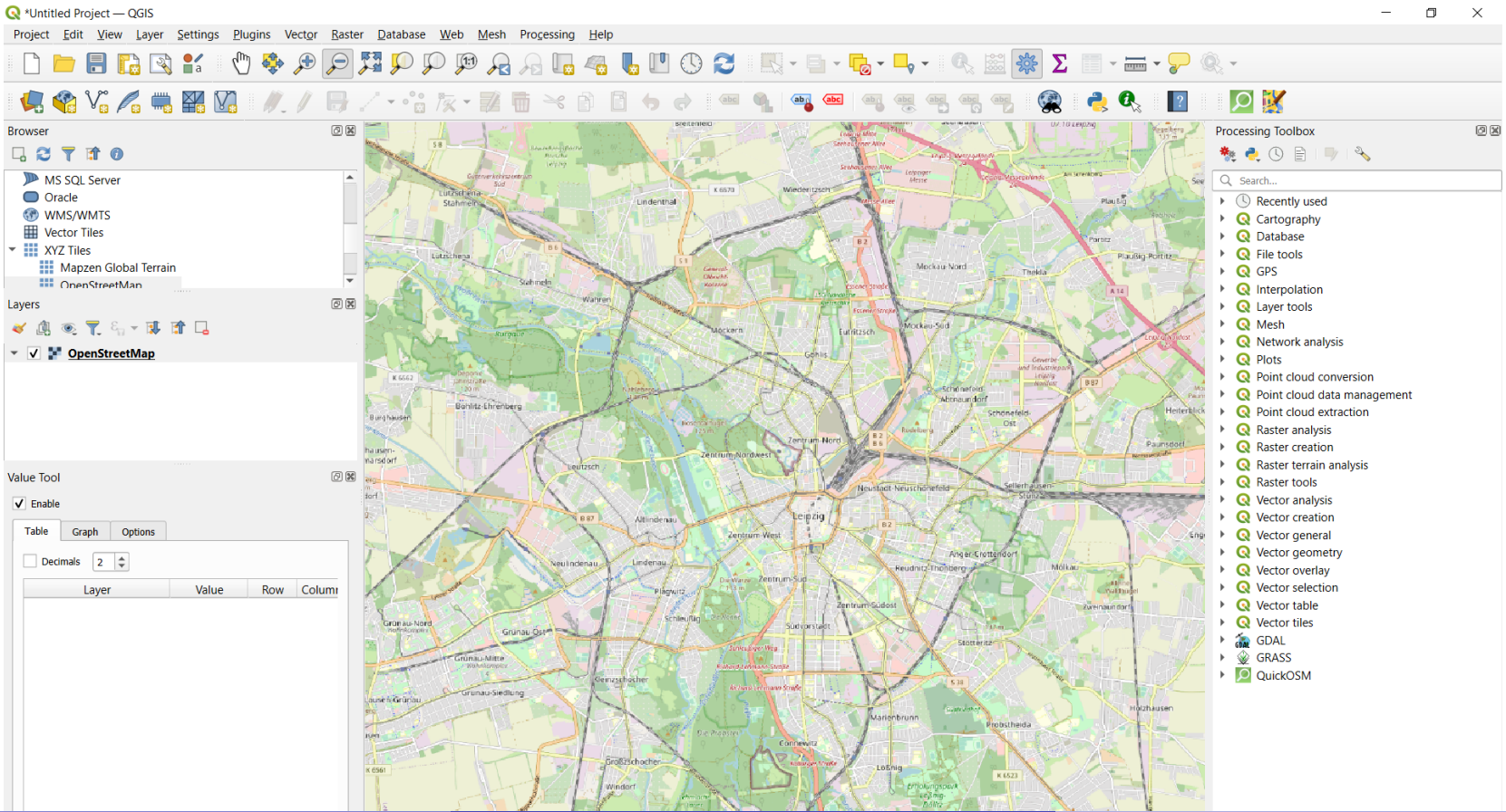
Table 4
Vertical Location By Industry[a].

	(1) All Industries	(2) Retail (Sic2 52–59)	(3) Not Retail (Not Sic2 52–59)	(4) Business Services (Sic2 73)	(5) Law Offices (Sic2 81)	(6) Brokerage Offices 12 MSAs (SIC 62)	(7) Insurance Carriers 12 MSAs (SIC 63)	(8) Insurance Agents, Brokers & Services (SIC 64)
1st Pctl	−2	−3	−2	−2	−2	−3	−3	−1
25th Pctl	5	1	7	5	14	12	7	9
50th Pctl	14	1	16	15	21	23	13	18
75th Pctl	24	5	26	24	32	31	26	24
99th Pctl	93	90	62	93	71	55	61	43
# Obs	5,445	209	2,829	255	611	268	64	74

- Look at the distribution of floor numbers by industry: The average (50th percentile) retail business is on the first floor, the average insurance firm on the 13th floor, with law offices (21th floor) and brokerages (23th floor) as the highest.
- Agglomeration effects: Doubling employment density in the zipcode area increases commercial rent by 10.7% on average.
- Firms are willing to pay for these agglomeration effects in a similar way as for higher floors: Adding 100,000 workers to the zipcode area has roughly the same impact on commercial rent as moving up 30 floors.

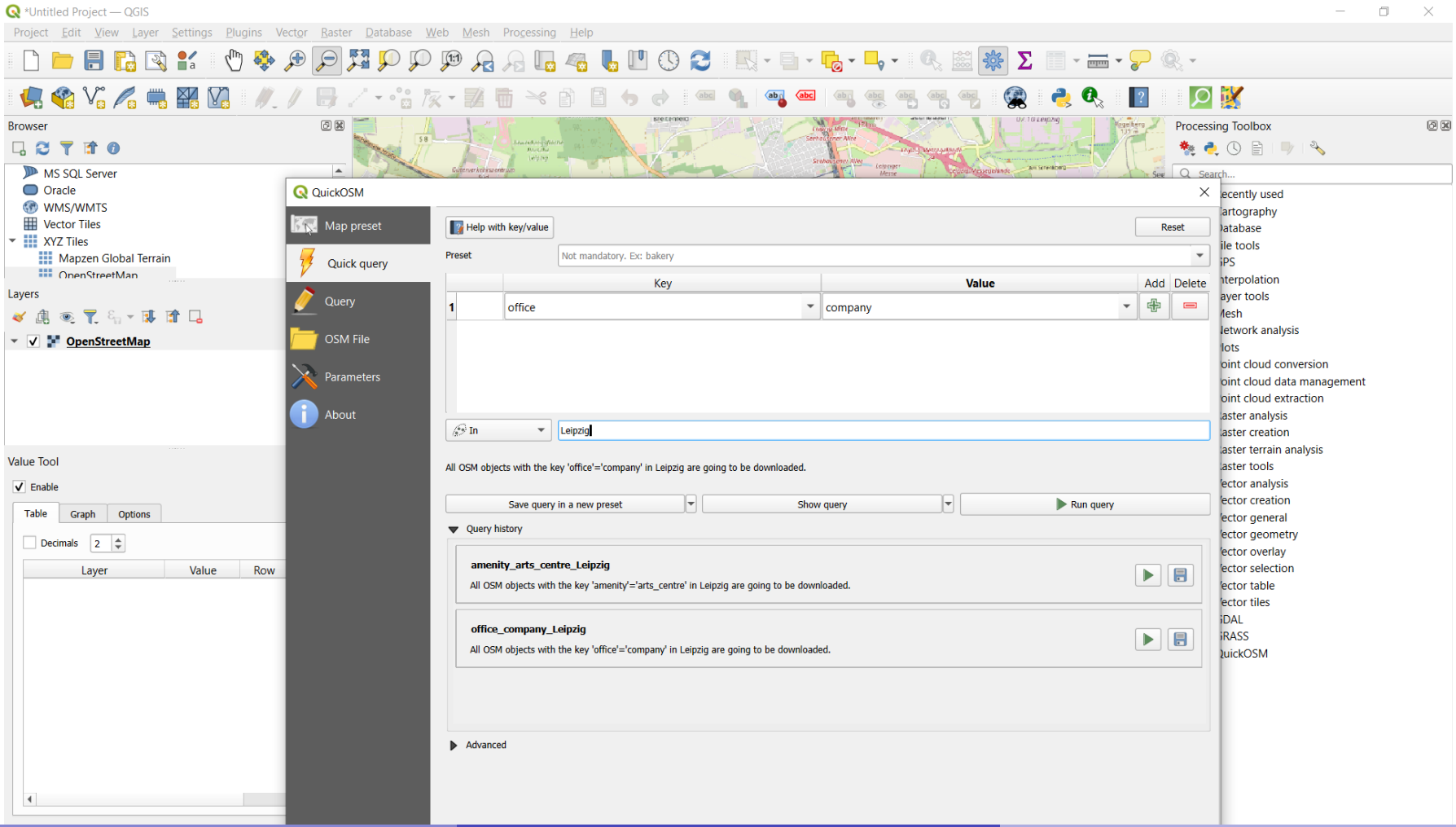
Exercise: Clusters of Firms in QGIS

- With geo-spatial data, we can see how close firms are to each other and which firms can be considered a cluster.
- Let us examine clusters of firms in Leipzig. Find the Open Street Map of Leipzig under *XYZ Tiles -> Open Street Map* of your *Browser* panel (*View -> Panels -> Browser*).



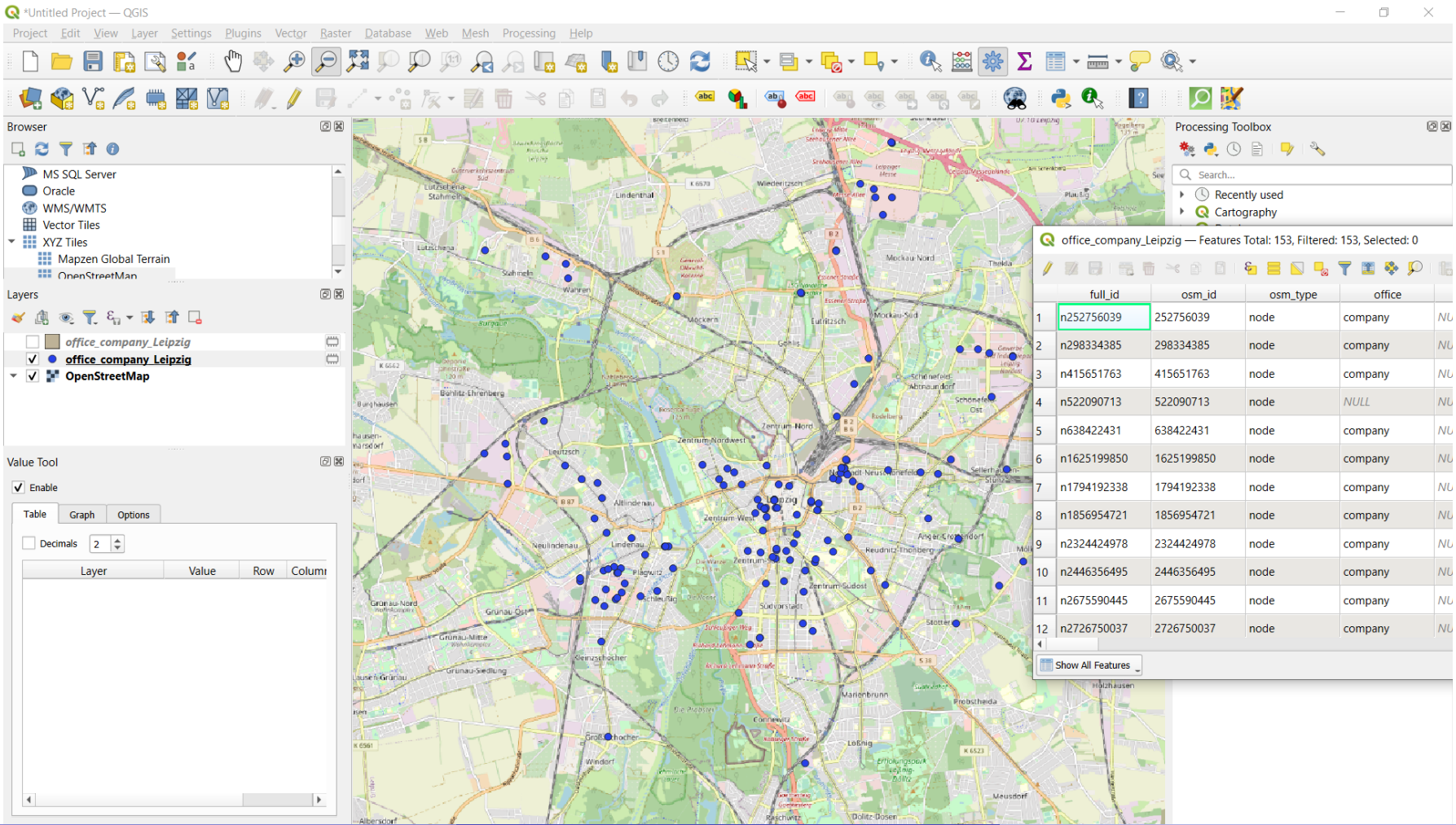
Exercise: Clusters of Retail Firms in QGIS

Obtain the retail firm data from *The QuickOSM* (Open Street Map) plugin: Selecting *Key = office*, *Value = company*, *IN: Leipzig*, *RUN QUERY* yields two layers with companies, one with the companies as points (more useful), one with them as polygons



Exercise: Clusters of Retail Firms in QGIS

Look how the firms are distributed across the map, with some in the center but smaller numbers of firms also clustering in other districts. Examine the information in the attribute table (by right-clicking on the points layer *office_company_Leipzig*).

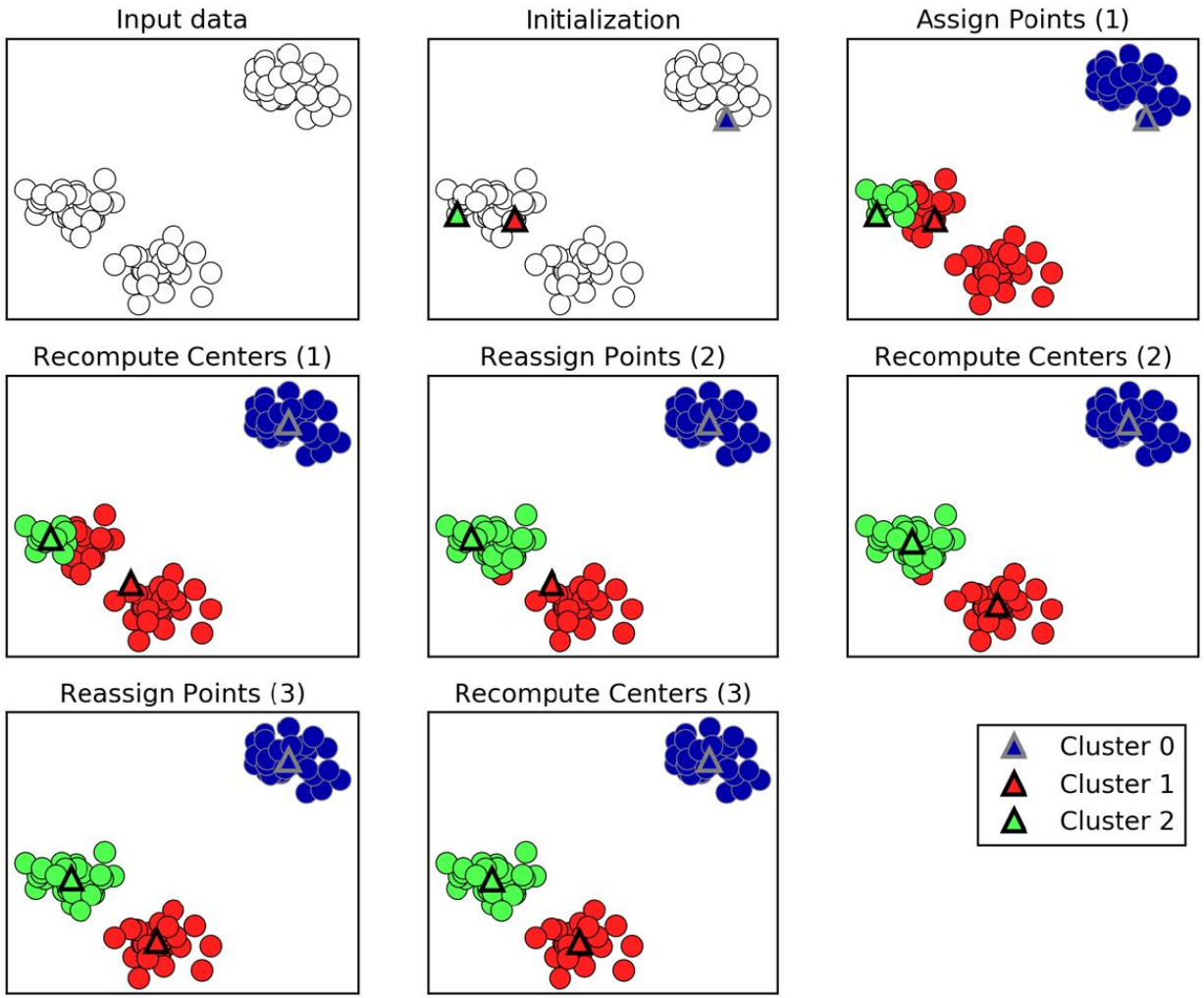


The k – *means* Clustering Algorithm

- Let us implement a clustering algorithm. **Clustering** is an unsupervised technique to partition the data set into smaller groups called clusters.
- The most widely-used clustering algorithm is **k-means**. It identifies clusters of points based on geographical distance.
  - There are numerous other applications of clustering, for example identifying clusters of topics in a blog or clusters of photos on social media sites. Then proximity is based on similarity of some characteristics rather than geographical distance.
- We need to set the number k of clusters in advance (a drawback!). Then the algorithm proceeds as follows:
  1. Initialization: It declares k points randomly as cluster centers.
  2. It assigns each data point to the distance-based closest cluster center
  3. It re-sets each cluster center as the mean of the points that are assigned to it (not necessarily one particular point)
  4. It repeats Step 2
  5. It repeats Step 3
  6. It continues until the assignment of the points no longer changes

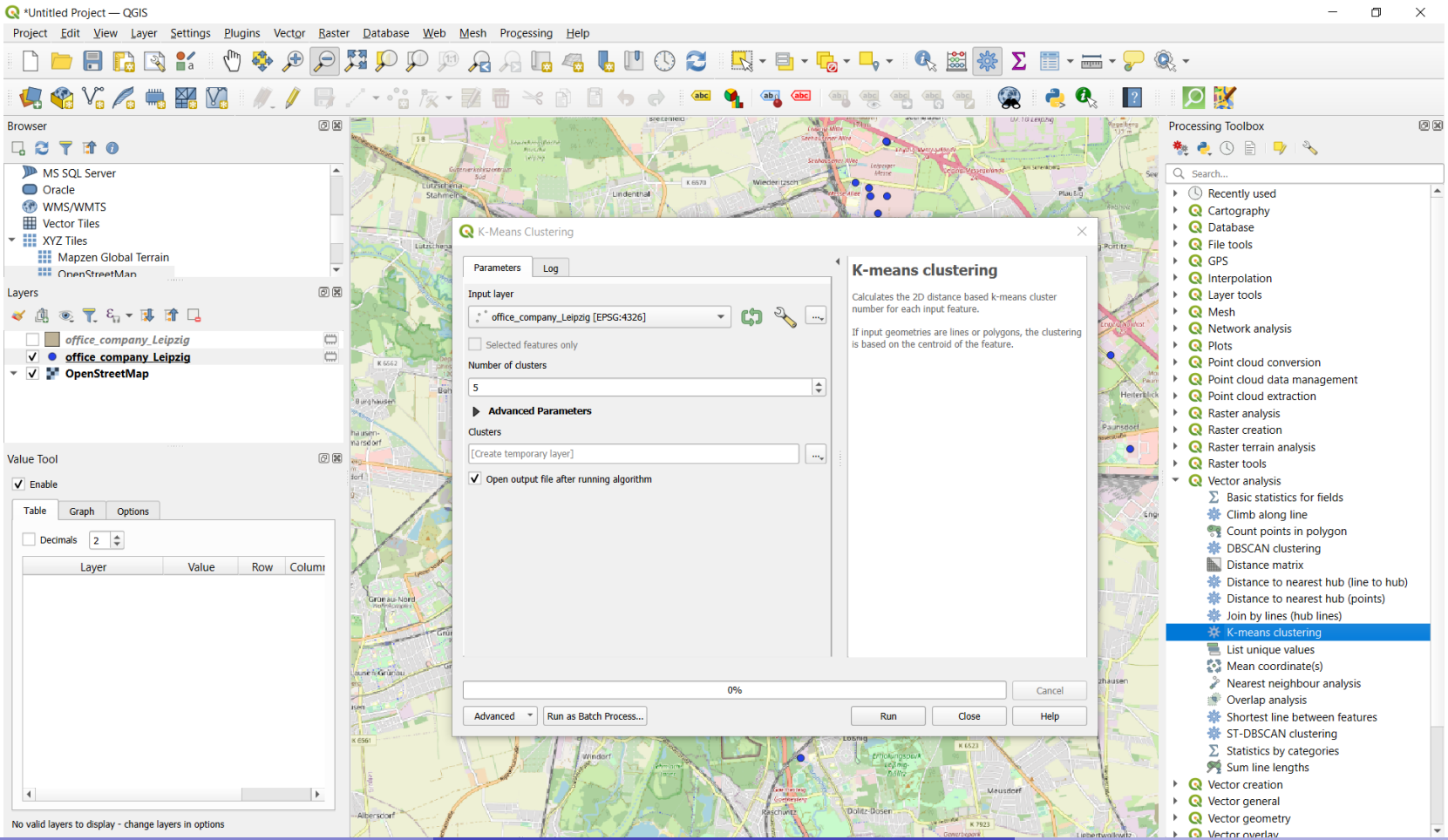
The k – *means* Clustering Algorithm

Illustration of the algorithm with three clusters (Source: Mueller and Guido 2017)



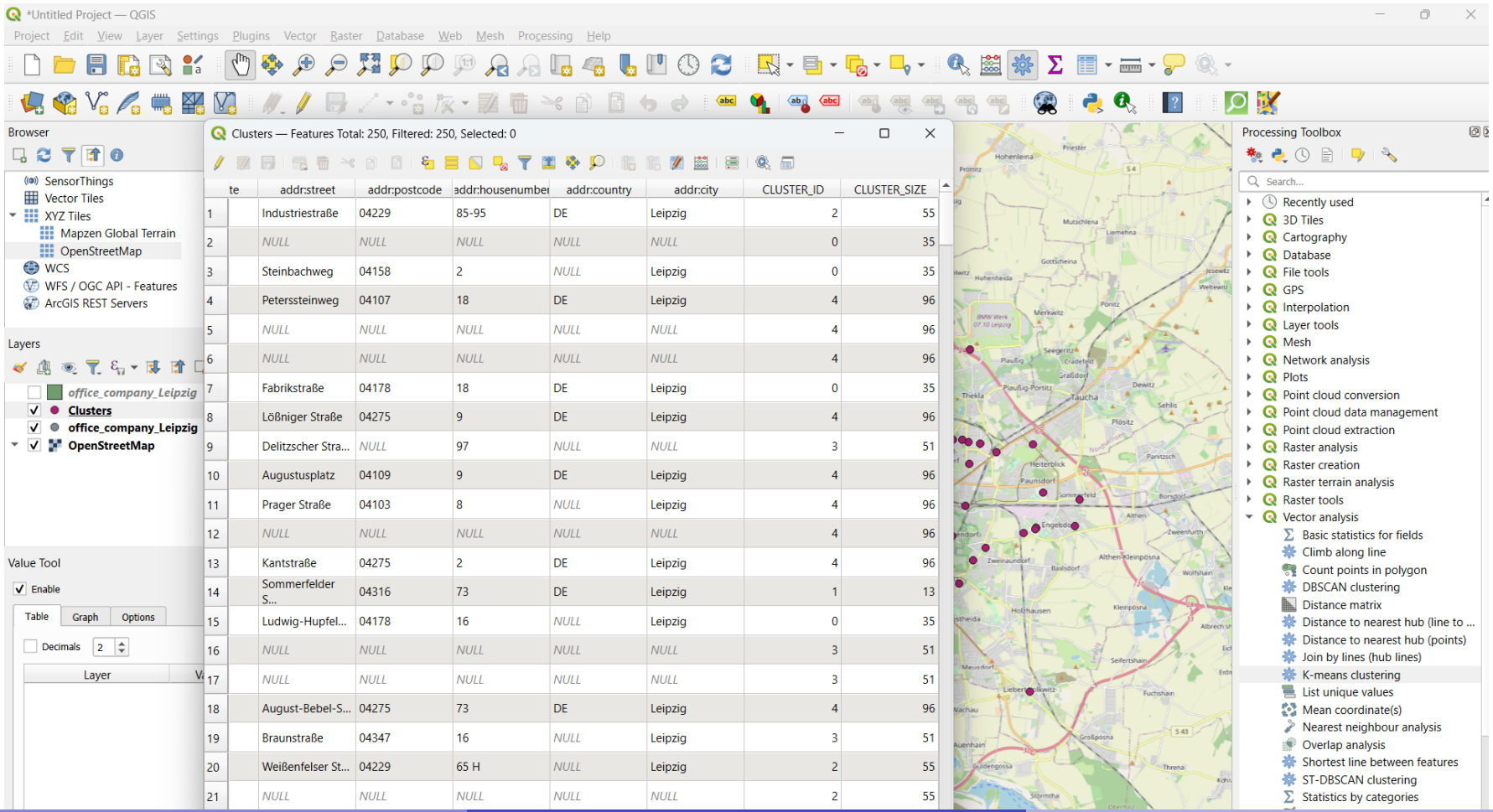
Exercise: Clusters of Retail Firms in QGIS

Let us conduct the k-Mean algorithm in QGIS to see how the algorithm groups the firms into five clusters based on their geographical distance. Go to *Processing Toolbox* → *Vector Analysis* → *k-means Clustering*. As input layer, choose *office_company_Leipzig*. Choose the number of clusters, here 5. (Try out a different number!)



Exercise: Clusters of Retail Firms in QGIS

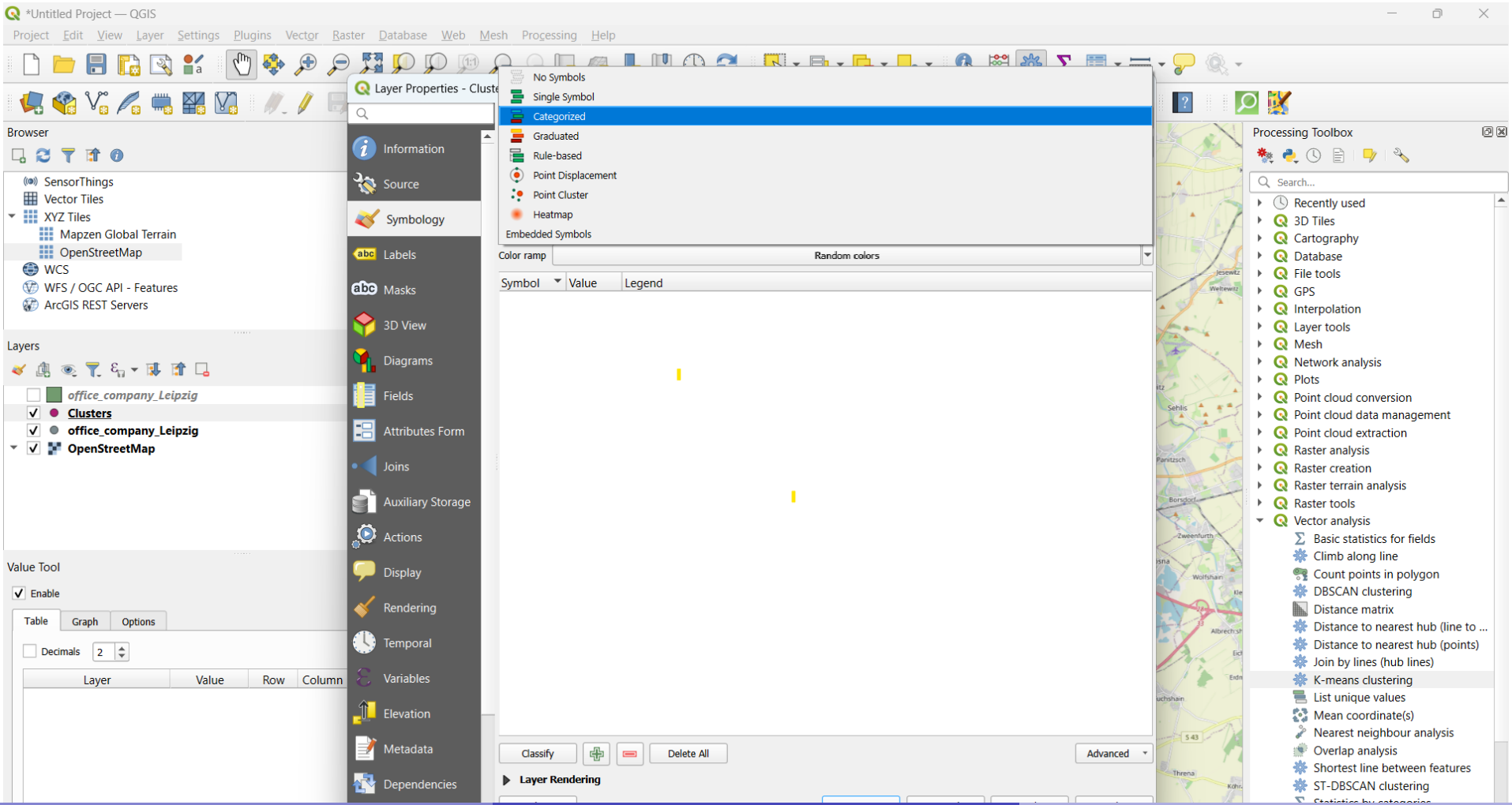
A new layer *Clusters* has been created. Right-click on it to see the attribute table: Two new columns have been added, indicating for each company the cluster it belongs to (*CLUSTER_ID*) and the number of companies in that cluster (*CLUSTER_SIZE*). E.g. cluster no. 0 has 35 companies, cluster no. 4 has 96 companies.



	te	addr:street	addr:postcode	addr:housenumber	addr:country	addr:city	CLUSTER_ID	CLUSTER_SIZE
1		Industriestraße	04229	85-95	DE	Leipzig	2	55
2		NULL	NULL	NULL	NULL	NULL	0	35
3		Steinbachweg	04158	2	NULL	Leipzig	0	35
4		Peterssteinweg	04107	18	DE	Leipzig	4	96
5		NULL	NULL	NULL	NULL	NULL	4	96
6		NULL	NULL	NULL	NULL	NULL	4	96
7		Fabrikstraße	04178	18	DE	Leipzig	0	35
8		Lößniger Straße	04275	9	DE	Leipzig	4	96
9		Delitzscher Stra...	NULL	97	NULL	NULL	3	51
10		Augustusplatz	04109	9	DE	Leipzig	4	96
11		Prager Straße	04103	8	NULL	Leipzig	4	96
12		NULL	NULL	NULL	NULL	NULL	4	96
13		Kantstraße	04275	2	DE	Leipzig	4	96
14		Sommerfelder S...	04316	73	DE	Leipzig	1	13
15		Ludwig-Hupfel...	04178	16	NULL	Leipzig	0	35
16		NULL	NULL	NULL	NULL	NULL	3	51
17		NULL	NULL	NULL	NULL	NULL	3	51
18		August-Bebel-S...	04275	73	DE	Leipzig	4	96
19		Braunstraße	04347	16	NULL	Leipzig	3	51
20		Weißenfelser St...	04229	65 H	NULL	Leipzig	2	55
21		NULL	NULL	NULL	NULL	NULL	2	55

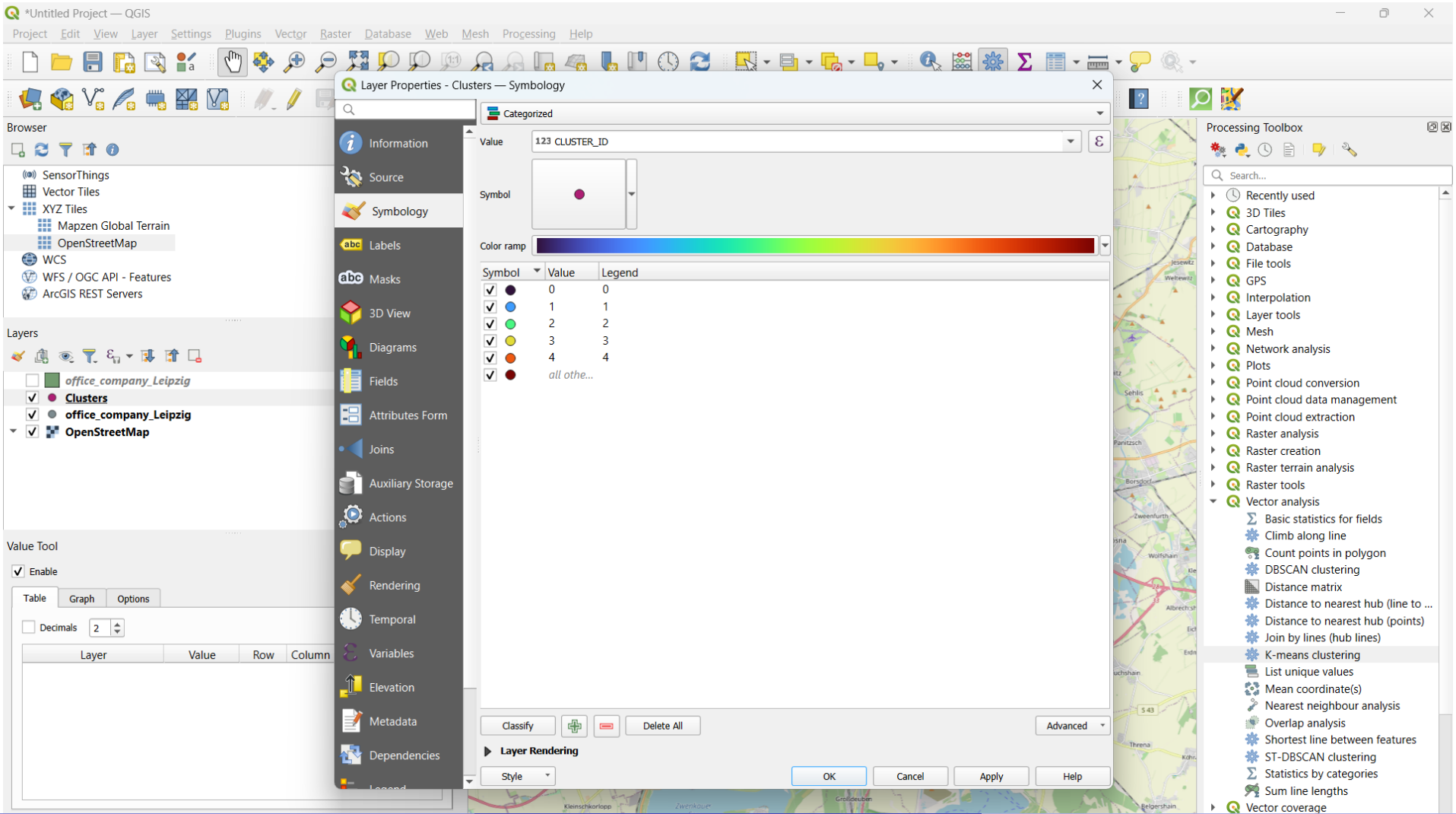
Exercise: Clusters of Retail Firms in QGIS

Visualize the points of each cluster in a different color: Right-click on the *Clusters* layer. Select *Properties* → *Symbology*. From the uppermost drop-down menu, choose *Categorized* rather than *Single Symbol*.



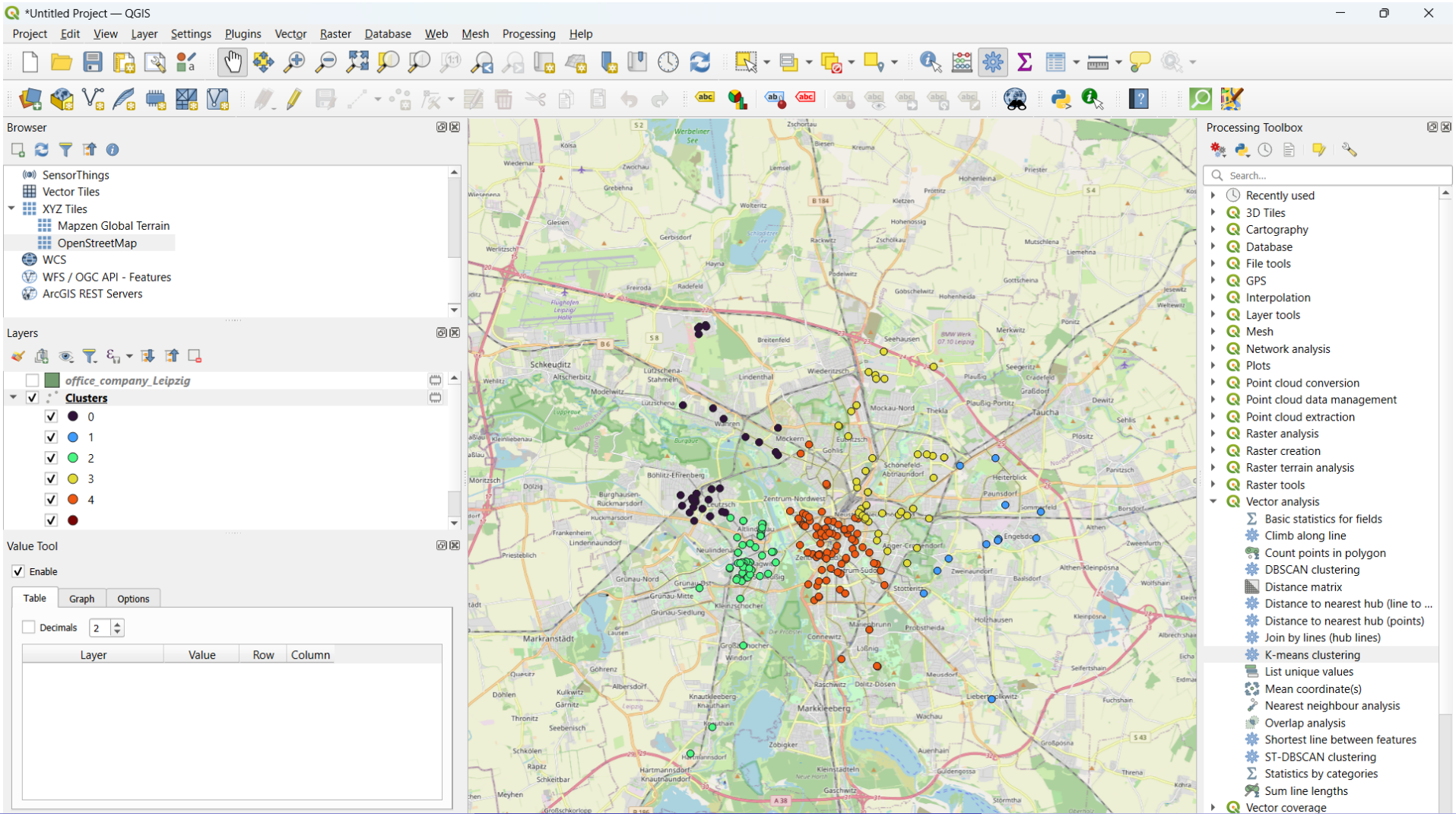
Exercise: Clusters of Retail Firms in QGIS

In the *Categorized* menu, select *Cluster_ID* as *Value* (ensuring that they determine the colors), then click on *Classify*. You may change the *Symbol* and the *Color Ramp*, if you wish.



Exercise: Clusters of Retail Firms in QGIS

Examine the resulting five clusters graphically. How do they correspond to city districts? What are advantages and shortcomings of the data and the algorithm?



Wrap-Up of Unit 12

- The **business location decision** is a complex combination of many factors: Business taxes matter, but so does affordable office space, infrastructure, the workforce, and the overall business environment.
- Firms benefit from the presence of others from the same industry thanks in **agglomeration effects**. There is empirical evidence that many firms are willing to bear a higher tax burden in order to be part of a cluster and benefit from agglomeration effects.
- Agglomeration effects increase with both the **size** and the **density** of a city. Their economic mechanisms work via **sharing, matching, and learning**.
- Spatial sorting of firms occurs not only horizontally but also **vertically** within a commercial building, where firms trade off the easy access of the ground floor with the higher amenity of top-floor offices.
- With geo-spatial data, a clustering algorithm such as **k-means** can yield some insights into which firms might be considered a geographical cluster.

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