**An example for Benchmarking application**

**Case study:** Düsseldorf

**Variable:** Human resources in science and technology (HRST) (% of active population)

The main essence for benchmarking is to compare a region within a wider group of selected areas, that have been specified based on a set of criteria. For example, tow possible types for analyses could be the following:

- sub-national analysis for a region: The main objective of this analysis is to compare a region to other regions of the same country. By following this type of analysis, the user wants to find the position of his/her region within the country, as well as get some results regarding intra-country inequality at a regional level.
- inter-national analysis for a region: In this case, the user wants to compare a region to other EU regions, that might have a similar structure, in terms of economic, demographic or geographical characteristics. By following this type of analysis, the user wants to define the position of his/her region within a group of similar regions, that in many cases might be its competitors, as well as get some results regarding inter-regional inequality at an EU level.

Based on these two possible types of analysis, we provide an example that follows the rationale of the second case. Let's say that the user tries to benchmark the region of Düsseldorf, compared to a set of 20 EU regions. These regions might have been defined through different processes, such as similar regions in terms of spatial characteristics (e.g. population density or sectoral structure). In our case we have chosen a sample of 20 EU regions based on population density, including some more sparsely populated areas just to indicate existing differences.

In the case of benchmarking, it is important for the user to understand that there is an extensive set of analyses that could be performed using this application. Each one of them could lead to different results, based on the selection of the group of regions, as well as the variables under investigation. Furthermore, it is essential to conduct a thorough theoretical analysis before starting comparing different regions, as the definition of the groups should be correctly justified by the user, in order to avoid the interpretation of misleading results.

*Step 1: Selection of input data*

First, we construct the table of data that will be uploaded on the application as input, in order to start comparing the chosen region, Düsseldorf in this example case. One solution is to use the Regional Assets Mapping application and export the data in a table format. Below, a screenshot from this application is presented indicating the way for extracting the data (**Fig.1a-b**).

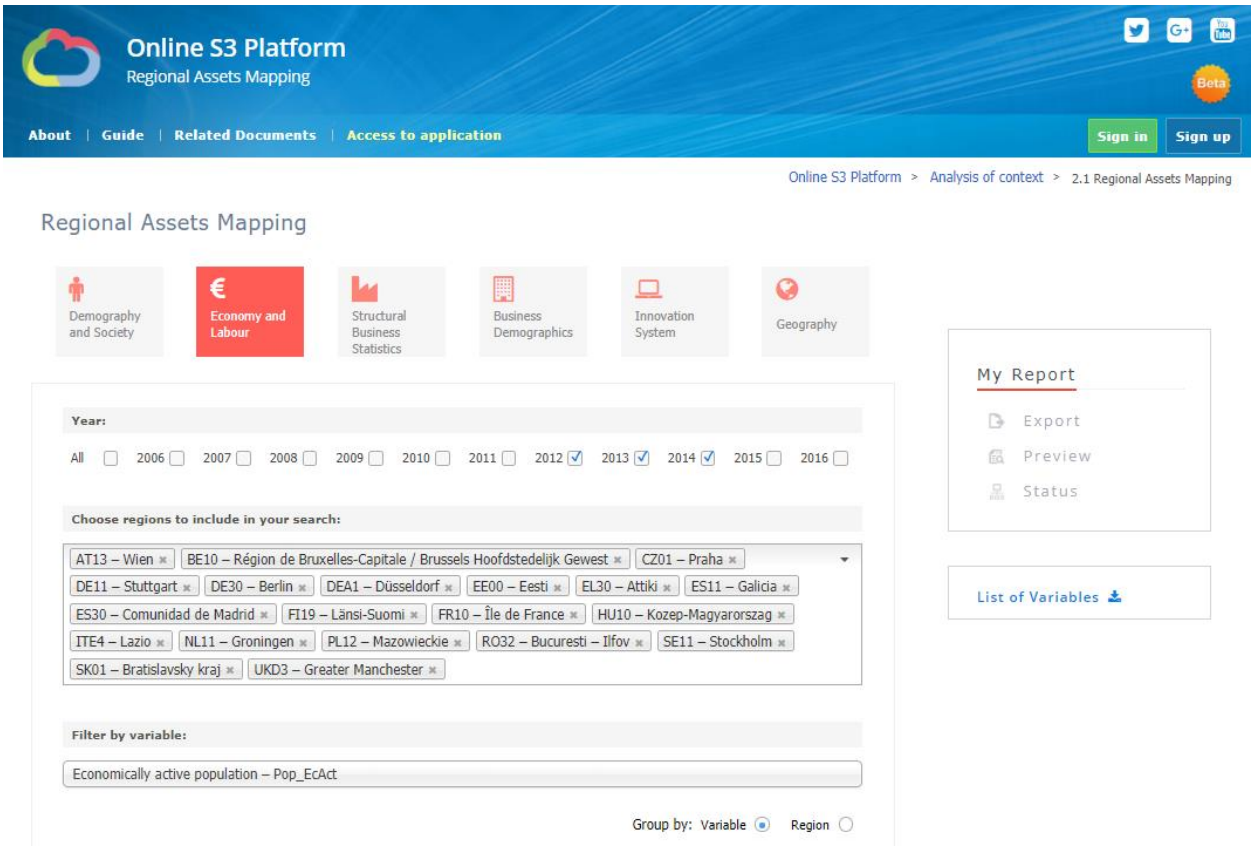



**Figure 1a:** Screenshot from the Regional Assets Mapping application during the creation of the input data for Benchmarking – Filters for searching.

We have selected a set of 20 EU regions to use as the comparison group for our focus region, which is Düsseldorf. The selection of the regions is a user's choice, depending on the type of comparisons that he/she wants to make for the analysis.

**Human resources in science and technology (HRST) (% of active population) – HRSTofActPop**

Percentage of total population

| Region | 2012 | 2013 | 2014 |
|---|---|---|---|
| AT13 – Wien | 25.00 | 26.20 | 25.80 |
| BE10 – Région de Bruxelles-Capitale / B... | 38.20 | 37.40 | 41.40 |
| CZ01 – Praha | 33.10 | 32.90 | 32.40 |
| DE11 – Stuttgart | 26.30 | 26.40 | 27.30 |
| DE30 – Berlin | 56.20 | 57.40 | 59.60 |
| DEA1 – Düsseldorf | 23.30 | 23.60 | 23.50 |
| EE00 – Eesti | 40.40 | 40.20 | 40.20 |
| EL30 – Attiki | 32.20 | 32.00 | 32.00 |
| ES11 – Galicia | 12.80 | 12.50 | 13.00 |
| ES30 – Comunidad de Madrid | 47.20 | 46.60 | 46.40 |
| FI19 – Länsi-Suomi | 21.00 | 22.30 | 23.00 |
| FR10 – Île de France | 52.60 | 52.40 | 52.80 |
| HU10 – Kozep-Magyarorszag | 44.60 | 46.20 | 48.60 |
| ITE4 – Lazio | 17.10 | 17.40 | 18.40 |
| NL11 – Groningen | 24.60 | 24.20 | 23.90 |
| PL12 – Mazowieckie | 22.50 | 22.50 | 23.70 |
| RO32 – Bucuresti – Ilfov | 22.50 | 20.20 | 21.70 |
| SE11 – Stockholm | 35.30 | 36.50 | 37.80 |
| SK01 – Bratislavsky kraj | 31.70 | 29.60 | 30.80 |
| UKD3 – Greater Manchester | 21.20 | 21.70 | 22.40 |

Download Show Graph Insert to Report

**Figure 1b:** Screenshot from the Regional Assets Mapping application during the creation of the input data for Benchmarking – Final table results after searching.

After we have selected the variable and the regions we want to use, we download the data in a .xlsx format.

*Step 2: Upload of input data*

As a next step, we have to upload the data that we have downloaded in the previous step on the Benchmarking application. We click on the Browse button, in order to select the file that we want to upload (**Fig.2**). The data will then be shown automatically in our screen (**Fig.3**).

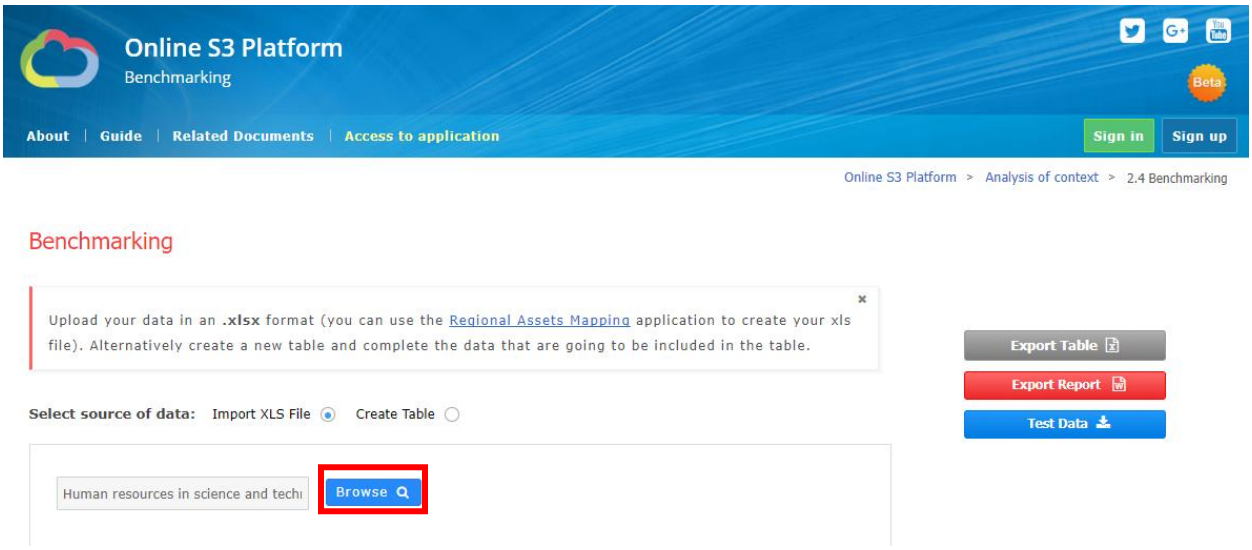



**Figure 2:** Uploading the data for Benchmarking.

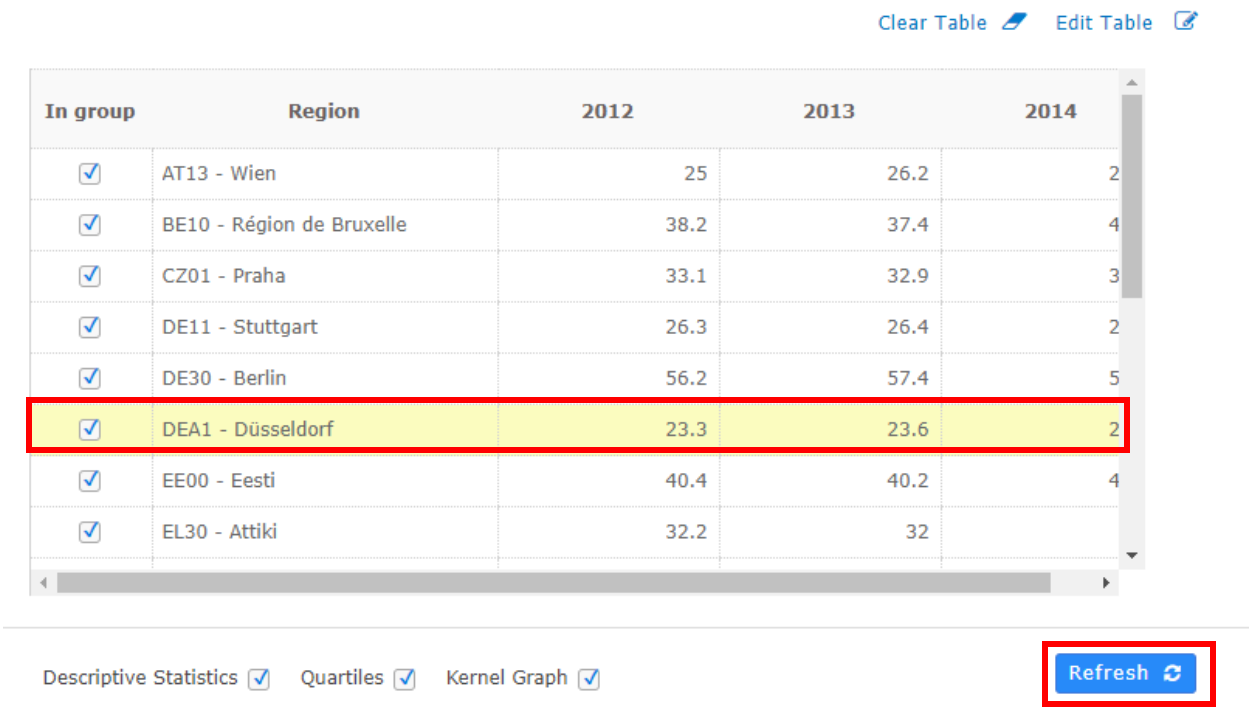



**Figure 3:** Data display for Benchmarking.

*Step 3: Benchmarking analysis*

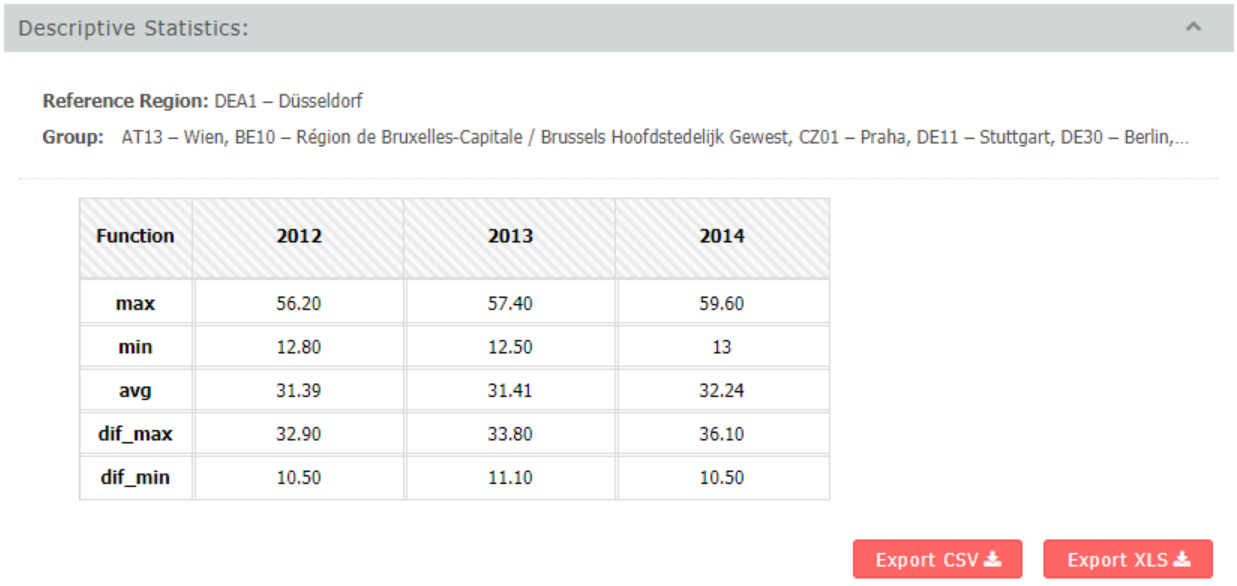
As a next step, we choose our reference region in order to use it as baseline for making future comparisons within the application. Düsseldorf has been selected in our case (**Fig.3**). It is important to understand that we cannot get any results from benchmarking, unless we select out reference region. By pressing *Refresh*, three different types of results are displayed on the screen.

Descriptive statistics

For each year a set of descriptive values are illustrated (**Fig.4**):

- min, max: minimum and maximum values of the variable within the defined group of regions,
- avg: average value of the variable of the selected group of regions,
- dif_max, dif_min: difference of the reference region from the minimum and maximum values of the group.

In our example, the minimum and maximum values for the year 2012 are 12.80% and 56.20%, respectively. Moreover, the average share of human resources in science and technology for the selected group of regions is 31.39%. Based on this, Düsseldorf with a 23.30% share stands below the average of the group, and is 32.90 percentage units lower than the region with the highest share and 10.50 percentage units higher than the region with the lowest share.




| Function | 2012 | 2013 | 2014 |
|---|---|---|---|
| max | 56.20 | 57.40 | 59.60 |
| min | 12.80 | 12.50 | 13 |
| avg | 31.39 | 31.41 | 32.24 |
| dif_max | 32.90 | 33.80 | 36.10 |
| dif_min | 10.50 | 11.10 | 10.50 |

**Figure 4:** Descriptive statistics for the group of regions.

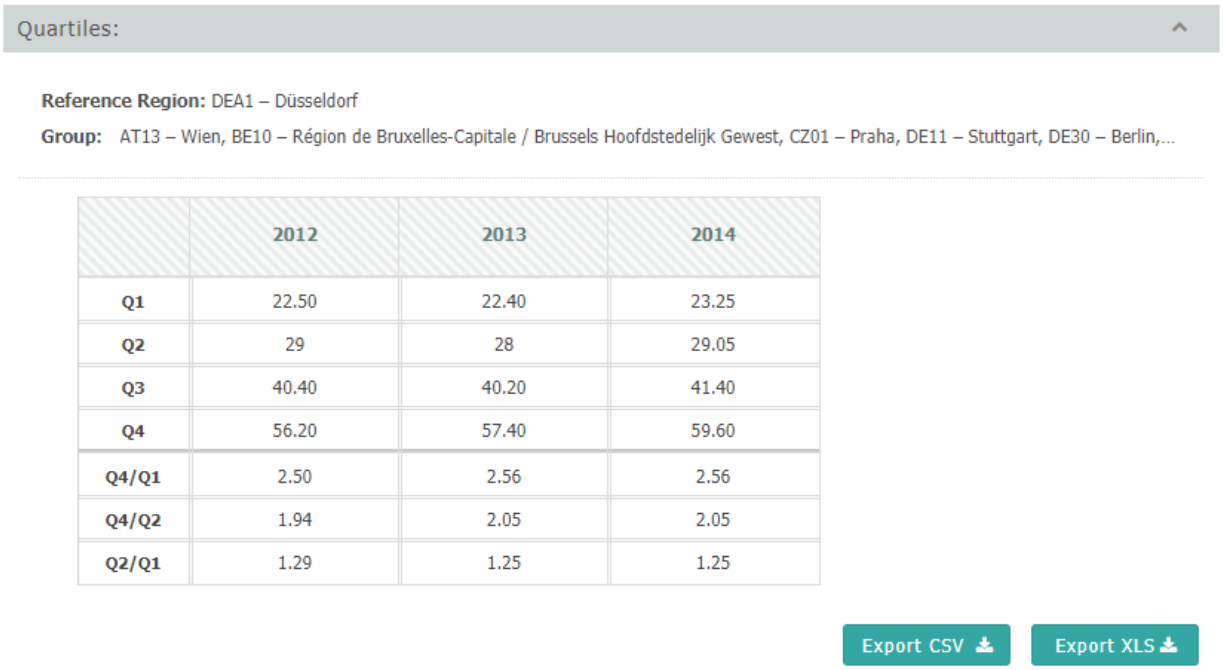
Quartiles

The boundaries for the quartiles for each year are illustrated in the net section of results. Each quartile includes a share of 25% of the regions, starting from lowest to highest rates. More specifically,

- Q1: includes the bottom 25% percent of the regions

- Q2: includes the regions belonging to 25-50% percent of the distribution
- Q3: includes the regions belonging to 50-75% percent of the distribution
- Q4: includes the top 25% percent of the regions

As it is shown in **Fig.5**, these boundaries change throughout time, and specifically in our example indicate an increasing trend of share of human resources in science and technology for the selected group of regions.




| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Q1 | 22.50 | 22.40 | 23.25 |
| Q2 | 29 | 28 | 29.05 |
| Q3 | 40.40 | 40.20 | 41.40 |
| Q4 | 56.20 | 57.40 | 59.60 |
| Q4/Q1 | 2.50 | 2.56 | 2.56 |
| Q4/Q2 | 1.94 | 2.05 | 2.05 |
| Q2/Q1 | 1.29 | 1.25 | 1.25 |

**Figure 5:** Quartile statistics for the group of regions.

Another important part of this analysis is the quartile ratios that are also given in this section. By looking at these values, the user can get a better understanding of the inequality arising between the selected regions. One of the most common indicators is the Q4/Q1 ratio, that shows the ratio between the highest and lowest quartile. In the example we illustrate here, this ratio increases between 2012 and 2013 indicating a rise in inequality between the highest and lowest quartiles. This means that the gap between the regions indicating the lowest shares of human resources in science and technology and those with the highest shares widens. At the same time there seems to be an opposite movement in the case of Q2/Q1 ratio, which illustrates the inequality between the two lowest quartiles of the distribution. This means that we have a decrease in inequality in this set of regions.

Despite the numeric information given in the previous table, it is important to illustrate quartile results in a more schematic representation. As a result, it is possible to download a table indicating the corresponding quartile for each region, for each year separately. The table for our example is given below (**Fig.6**). By looking at the results, it becomes evident which regions belong to the highest and lowest quartiles or the distribution. As it is shown, Düsseldorf belongs to the second quartile of the share distribution, meaning that its share of human resources in science and technology is between the 25% and 50% of the overall distribution of the selected regions.

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| AT13 - Wien | 25 | 26.20 | 25.80 |
| BE10 - Région de Bruxelles- | 38.20 | 37.40 | 41.40 |
| CZ01 - Praha | 33.10 | 32.90 | 32.40 |
| DE11 - Stuttgart | 26.30 | 26.40 | 27.30 |
| DE30 - Berlin | 56.20 | 57.40 | 59.60 |
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| EE00 - Eesti | 40.40 | 40.20 | 40.20 |
| EL30 - Attiki | 32.20 | 32 | 32 |
| ES11 - Galicia | 12.80 | 12.50 | 13 |
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| RO32 - Bucuresti - Ilfov | 22.50 | 20.20 | 21.70 |
| SE11 - Stockholm | 35.30 | 36.50 | 37.80 |
| SK01 - Bratislavsky kraj | 31.70 | 29.60 | 30.80 |
| UKD3 - Greater Manchester | 21.20 | 21.70 | 22.40 |

Q1 Q2 Q3 Q4

**Figure 6:** Quartile distribution table for the selected regions.

Kernel diagram

The final step for providing a sophisticated benchmarking analysis during the development of a RIS3 strategy, is the production of the Kernel diagram for the selected group of regions. This diagram shows the distribution of values for a specific variable throughout the full set of regions. Fig.7 illustrates the results for 2013. As we can see, there is a higher concentration of regions around shares between 20% and 30%. Düsseldorf is included in this range as its share of human resources in science and technology is 23.60%. what can also be commented by looking at Fig.7 is the fact that the distribution is not normal, indicating a positive skewness trend.

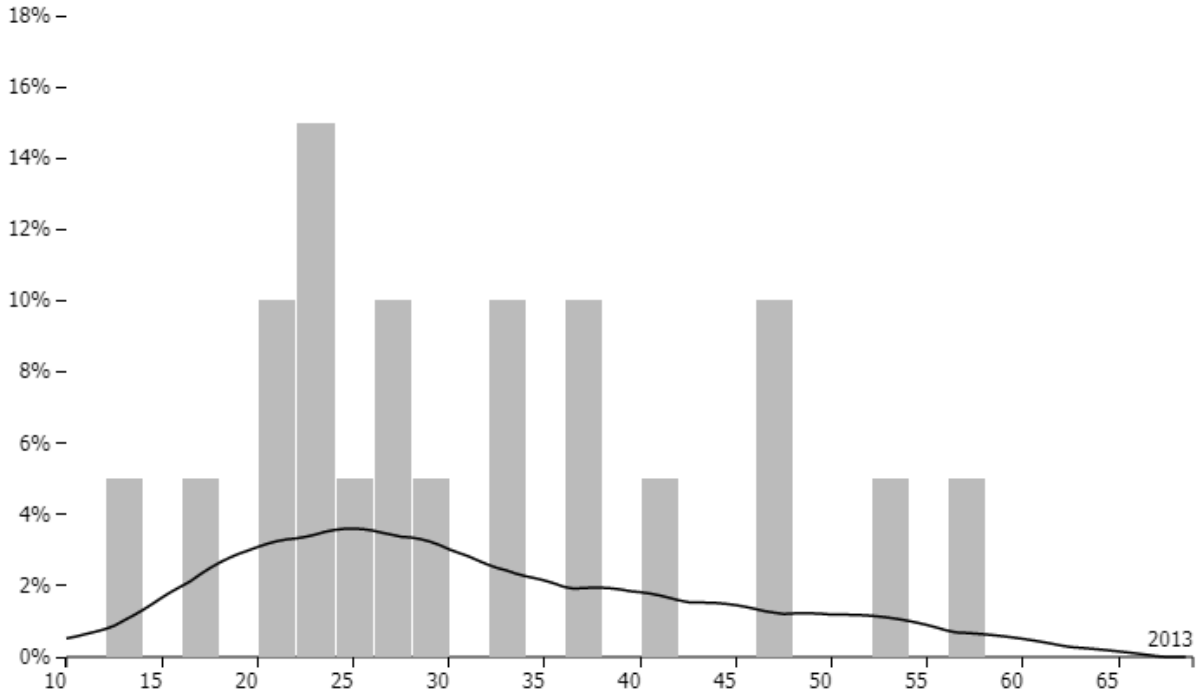


**Figure 7:** Kernel diagram for the selected set of regions.