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Spatial Analysis, Exercise 3

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1. INTRODUCTION

The location of mining and quarrying generally reflects the spatial distribution of mineral deposits, and mining employment. However, there can be considerable cost differences between mines, for example, in relation to the depth at which deposits are found, or whether they are on land or at sea. (Eurostat, 2024). According to Statista (2024), in terms of value added within the mining and quarrying sector in europe. 2021 data shows that Sweden has the third largest, accounting for 7.1%. In Sweden, most of the mining and quarrying activities takes place within the Northern municipalities. The Geological survey of Sweden (2023), indicates that Sweden's mineral resources and mineral reserves mostly occur in the three main ore districts of Norrbotten and Skelleftefältet, both in northern Sweden, and Bergslagen in south central Sweden. This study concentrates keenly on Northern Sweden as the largest contributor to the mining and quarrying sector. Jämtland, Västernorrland, Västerbotten, and Norrbotten collectively represent Northern Sweden, which are historically significant regions playing a crucial role in shaping the regional economies, labor markets and socio-economic landscapes, through mining and the quarrying sector. According to the Geological survey of Sweden (2023), 10,610 persons were employed by the Swedish mining industry, this was against the 8,045 record in 2022. The large increase is partly because figures for 2023 include more reliable estimates of the number of subcontractors.

2. AIM

The Main aim of this report is to examine at the Deso Level, the spatial and regional variations in the employment share of the mining and quarrying industry throughout Northern Sweden. Within the mining and quarrying sector across Northern Sweden at the Deso Level. This would be achieved by engaging spatial statistics and GIS-based visualization.
The study would examine patterns of mining employment within Northern Sweden and explore the relationship of persons employed within the mining and quarrying sector and education. With the use of spatial statistics and GIS-based visualization this study would look at employment trends in mining within Northern Sweden and investigate the connection between education and those working in the mining and quarrying sector.

3. THEORY

Mining and quarrying activities have long been associated with regional economic development, often serving as economic anchors for peripheral regions.The case is the same in Northern Sweden, as the region with most prominent mining activities. Guillain & Le Gallo (2010) emphasize the role of spatial clustering in economic activities, highlighting how industries such as mining influence labor markets and regional inequalities. Patacchini & Rice (2007) similarly explore economic performance and emphasize the importance of spatial statistics in identifying clusters and disparities.

4. METHOD AND DATA

I. Stata

Stata, the Statistical analysis software, was used for data analysis. Computed measures of central tendency and dispersion of Share of employed (16–64 years) working in: Mining and quarrying sector `(empl_mining)`. This was achieved both for county level and municipality group type.Utilizing the 2016 dataset comprising demographic and socio-economic variables across Sweden, with approximately 6,000 DeSO units. To focus on the northern Sweden study area, the data was filtered to include only the 570 relevant DeSO units using the `keep if` command. Summary statistics, including mean and standard deviation, were calculated for the entire study area using the `summarize` command. These statistics were further disaggregated at the county and municipality group levels to explore spatial variations. To ensure accurate weighting for the population aged 16–64, the `aweight` option was applied during data aggregation using the `collapse` command.

Boxplots were generated to visualize differences in the share of workers in the mining sector across counties and municipality groups using the `graph box` command. Additionally, a scatterplot was produced to investigate the relationship between mining employment and education levels `scatter` command. For GIS integration, preparatory steps were taken in Stata by creating a new variable that consolidated the two existing age groups using the `gen` command. The mean values for mining employment and education were then calculated for each municipality group using `collapse`. The resulting datasets, along with the original DeSO-level data, were exported as text files for use in ArcGIS Pro.

II. Geographical Information System(GIS)

The GIS dataset contained three distinct shapefiles: one for Sweden's 6,000 DeSO units, another representing Sweden's 290 municipalities, and a third showing the land area of Sweden. To prepare for the analysis, data from Stata was joined with these shapefiles using the '`Join Field`' tool in ArcGIS Pro. To focus on the study area, which included 570 DeSO units and 44 municipalities in Northern Sweden, new layers were created by selecting the relevant units and applying the 'Clip' tool to exclude unnecessary areas.

Spatial autocorrelation in the share of mining employment `empl_mining` was analyzed using two Moran's I tools. The 'Global Moran's I' tool provided an overall measure of spatial autocorrelation, identifying whether the data exhibited clustering, randomness, or dispersion across the study area. To gain a deeper understanding of spatial patterns, the 'Anselin Local Moran's I' tool was used. This tool generated a map visualizing spatial clusters and outliers, providing localized insights into the spatial distribution of mining employment.

Several decisions were made regarding the settings for spatial weight matrices, as these significantly influence the results. The study area presented challenges due to varying distances within the inland and coastal regions. An inverse distance weighting matrix was generated, prioritizing closer neighbors while still including all observations. To balance these spatial variations, a threshold distance of 74894,1952 meters was applied, capturing regional patterns due to the dispersed nature of mining activities and the geography of Northern Sweden. This larger distance reduces sensitivity to local variations and would lay emphasis on broader trends. Additionally, smaller thresholds were considered but appear to exclude meaningful relationships in sparsely populated regions. Finally, a bivariate map was created to examine the relationship between the share of mining employment and university education levels at the municipality level. The symbology was set to bivariate colors with a diamond-shaped color scale, where high values appeared as darker shades and low values as lighter shades. This design choice enhanced interpretability by visually emphasizing areas of significant mining employment and educational attainment.

5. RESULT

I. Standard Deviation and mean values among Mining workers

The share of employment in the mining and quarrying sector varied significantly across DeSO units, with the highest concentrations observed in Norrbotten County. The Calculations for Central tendency measures revealed Mean mining employment of **1.187274%** (with a standard deviation of **3.743204%**). This shows that within the regions of study in Northern Sweden, 1.18% of persons within the ages of 16-64 works in the mining and quarrying industry.

In *Figure 1* (as seen below), The share of persons employed in the mining and the quarrying sector in Northern Sweden, shows that the workers vary from 0 -25.4% depending on the area. Furthermore this shows that in some of these areas, nobody works in the mining and the quarrying sector(As seen in the map below).

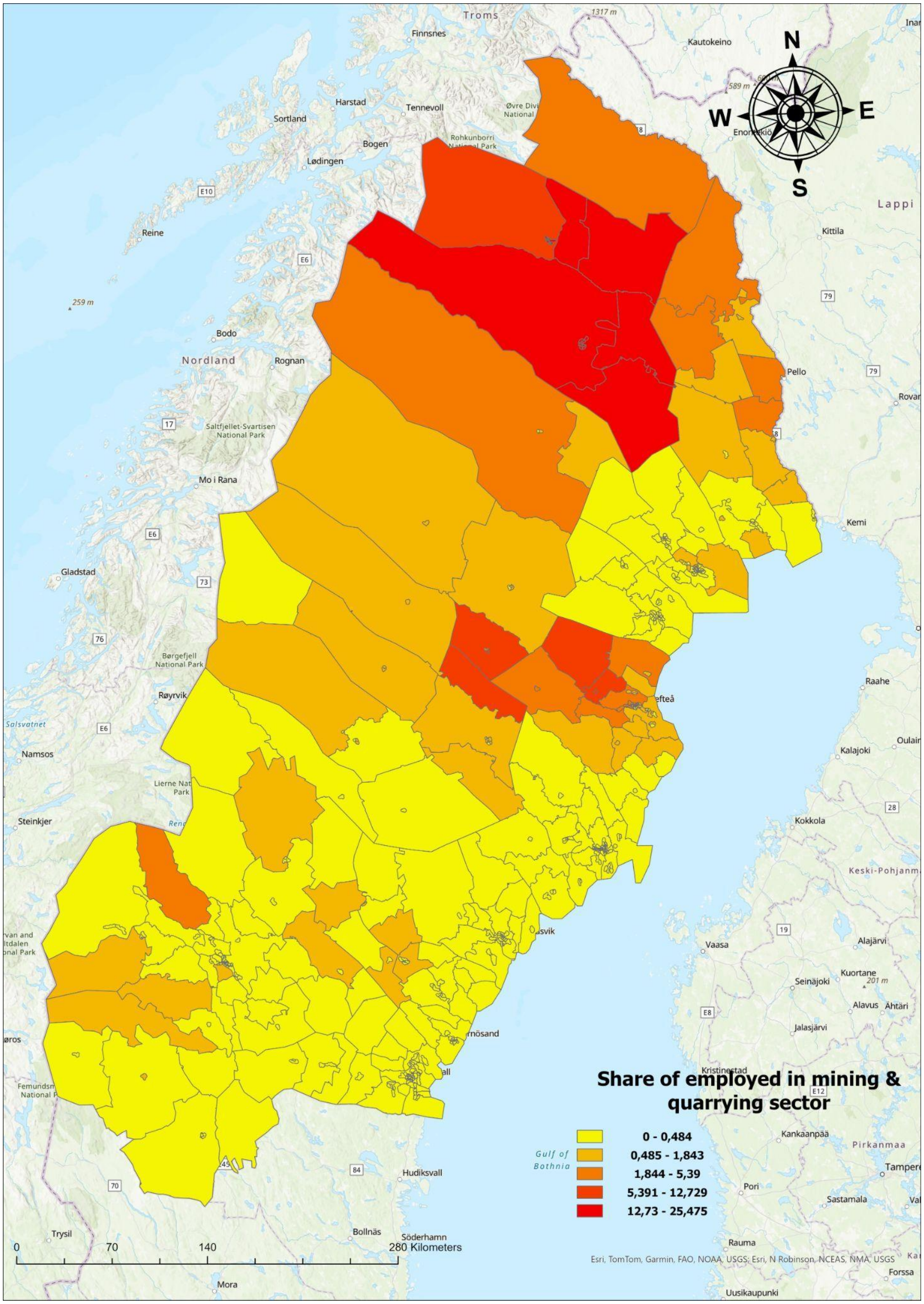

Figure 1. The share of employed in mining and quarrying sector

- From the Tables below: Table 1 and 2 shows specific mean and standard deviation for each of the Municipality groupings and the county as a whole. In *Table 1*, the mean and standard deviation of the different municipality groups are colour coded as follows:

  a. The medium-sized towns and municipalities near medium-sized towns (Red)

  b. Smaller towns/urban areas and rural municipalities(Green).

The comparison of B5(Lowest deviation) and C8 (Highest deviation), shows that C8 deviates further away from the values we observe in the mean. Getting a standard deviation of 6.16. This deviation is about 6 times more than the deviation observed in B5(0.17).

Main group	Municipality group	Municipality group code	Mean	Standard deviation
B. Medium-sized towns and municipalities near medium-sized towns	B3. Medium-sized towns	3	0.1366688	0.2364917
B. Medium-sized towns and municipalities near medium-sized towns	B4. Commuting municipalities near medium-sized towns	4	0.1324998	0.4580876
B. Medium-sized towns and municipalities near medium-sized towns	B5. Commuting municipalities with a low commuting rate near medium-sized towns	5	0.1531394	0.1753443
C. Smaller towns/urban areas and rural municipalities	C6. Small towns	6	2.295678	4.833834
C. Smaller towns/urban areas and rural municipalities	C8. Rural municipalities	8	2.776015	6.161322
C. Smaller towns/urban areas and rural municipalities	C9. Rural municipalities with a visitor industry	9	0.3955212	0.5617683

Table 1. Mean and Standard Deviation by Municipality Group

Country Name	Mean	Standard Deviation
Västernorrlands County	0.0596237	0.1168716
Jämtlands County	0.1625249	0.3371722
Västerbottens County	0.7659554	1.64041
Norrbottens County	3.08194	6.376687

Table 2. Mean and Standard Deviation by Counties

- From *Figure 2*, A boxplots was generated on stata to visualize the share of employed persons working in the mining and quarrying sector within the municipality groups of 3, 4, 5, 6, 8 and 9. The large outliers are as a result of mining towns that have a large share of the population working in mining. This would be considered to be statistically inconsistent with the overall population of other areas. Because of these mining towns, we see a sharp concentration of population in which a bulk of the individuals work in mining. The lines in the box illustrate the median observation. It is important to add that as seen in the box plot below, 8(which is C8) had the highest standard deviation, as illustrated in the plot below.

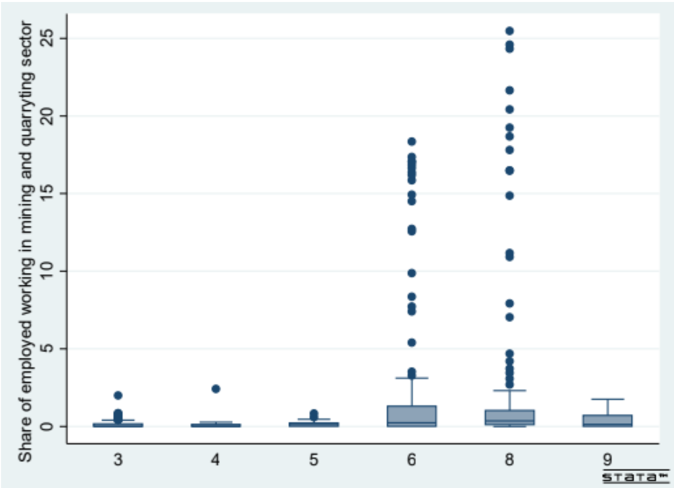

Figure 2. A boxplot over the share of population working in mining and quarrying sector at municipality group level

- From *Figure 3*, the illustration of the dispersion among the share of mining and quarrying workers at the country level

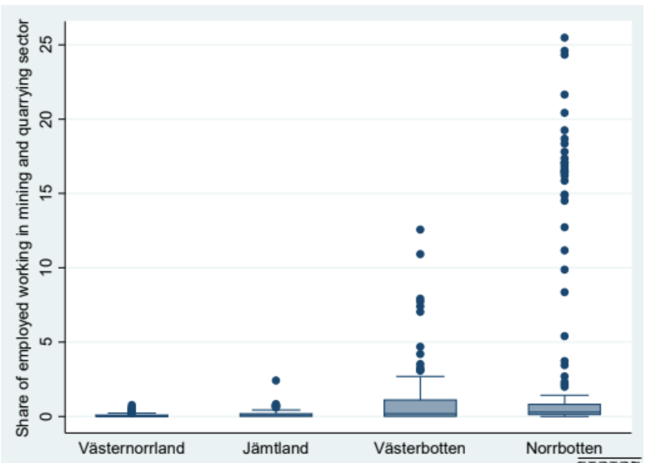

Figure 3. A boxplot over the share of the population working in the mining and quarrying sector at county group level.

II. Global and local Moran's I

In the presentation of Global Moran's I, the index of 0.900603 and a z-score of 54.917954 was obtained from ArcGispro. This indicates that the spatial distribution of the share of employment in mining and quarrying exhibits a strong level of positive spatial autocorrelation. This is so because the share of employment in mining and quarrying is highly clustered in certain areas.

Figure 4, below shows the visualization of the Local Moran's I. The pattern of clustering indicates a high level of clusterization around Kiruna and Gällivare.

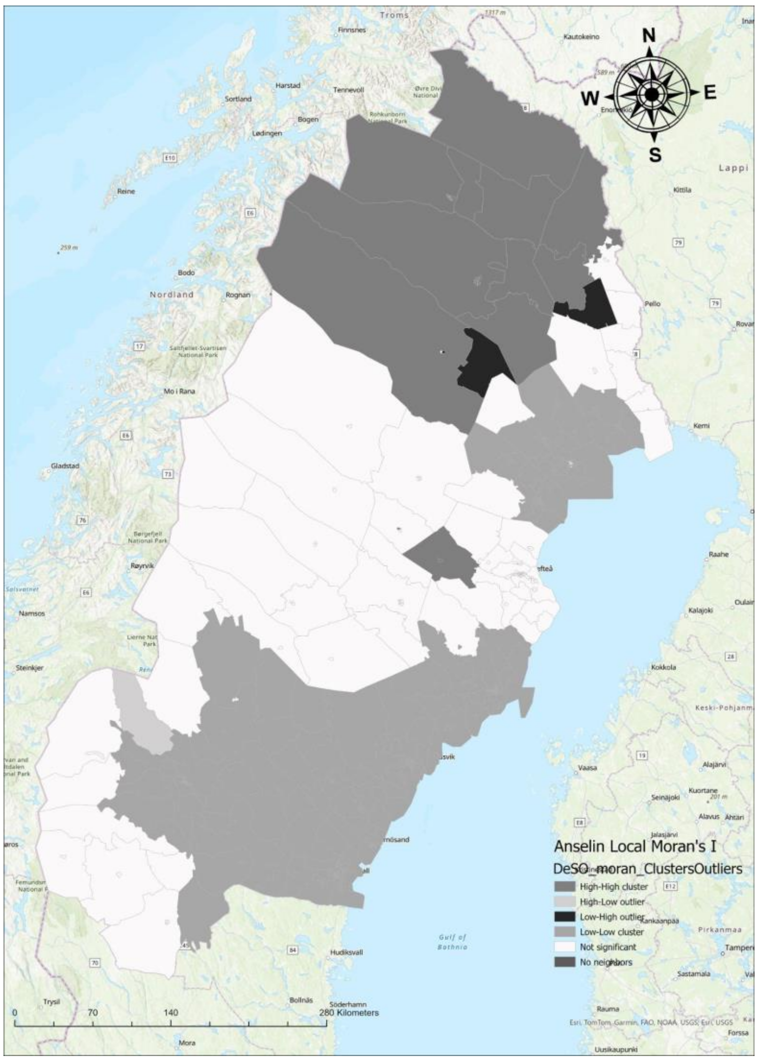

Figure 4. Local Moran's I model reveals clusters and outliers in the DeSO units and their share of the mining and quarrying sector.

III. Relationships between mining and quarrying workers and education

In the examination of the relationship between the share of mining & quarrying workers and the share of education (persons with university education) amongst the municipality groups. It is observed In *Figure 5*, that the scatter plot shows a negative relationship between the share of persons with university education and the share of employment in the mining and quarrying sector. The few outliers observed show higher shares of employment in the mining and quarrying sector. The Scatter Plot also shows that mining employment is highly concentrated in a few regions, despite overall low education attainment.

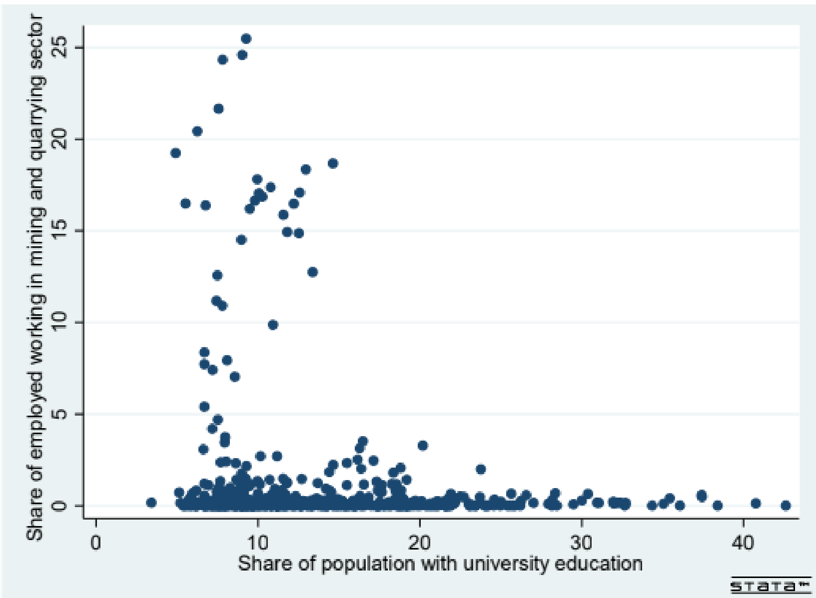

Figure 5. Scatter Plot illustrating the relationship between quarrying workers and education

- *Figure 6,* as seen below illustrate the relationship between the share of mining & quarrying workers and the share of education (persons with university education) amongst the municipalities.

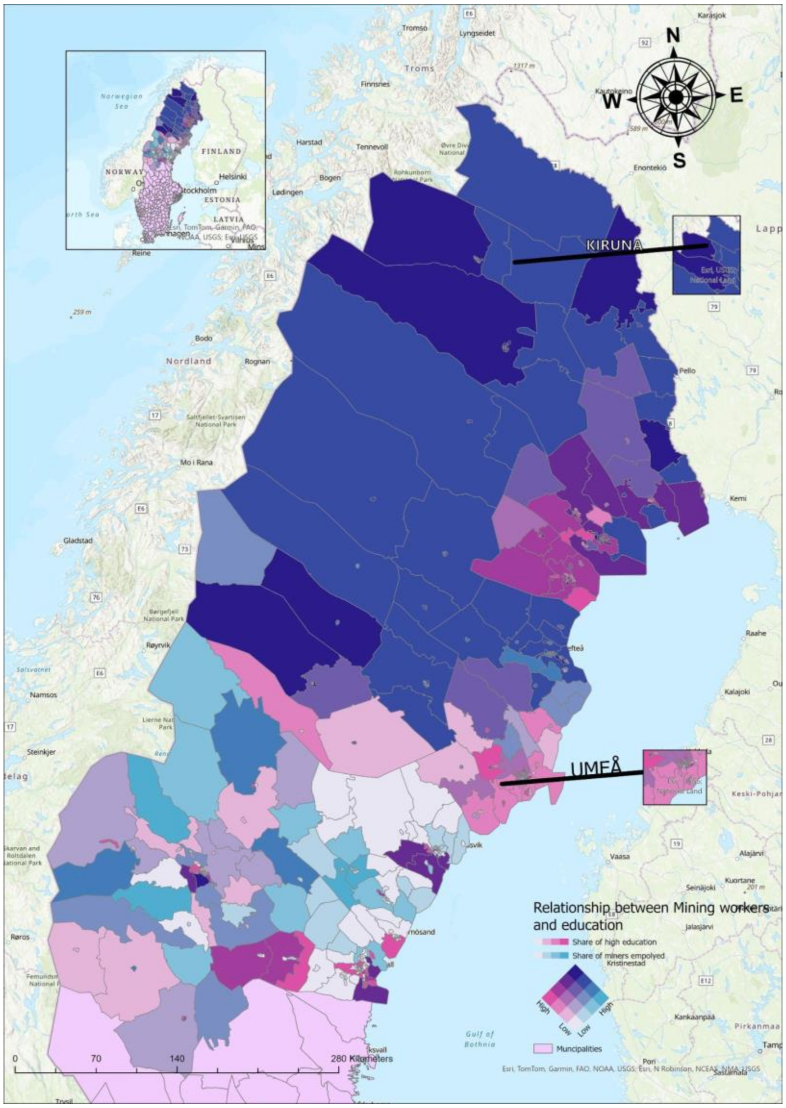

Figure 6. Bivariate map illustrating the relationship between health workers and education

6. DISCUSSION

The findings of this report shows the spatially uneven distribution of mining employment in Northern Sweden, with notable clusters in Norrbotten County, specifically within the areas of Kiruna.

These patterns draw attention to how economically dependent some areas are on the mining industry, which raises significant issues for regional development and labor market planning. A critical observation includes, the education amongst mining employees is low. Promoting higher education in mining-intensive areas could foster innovation and economic diversification, reducing dependency on extractive industries which are depleting according to the Geological survey of Sweden**, (2023).** The negative correlation with education levels suggests potential challenges in workforce development, as mining-dependent regions may require targeted investments in education and skills training to diversify their economies.

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