

Demographic Patterns in the City of Zagreb: Application of Advanced Spatial Statistical Methods

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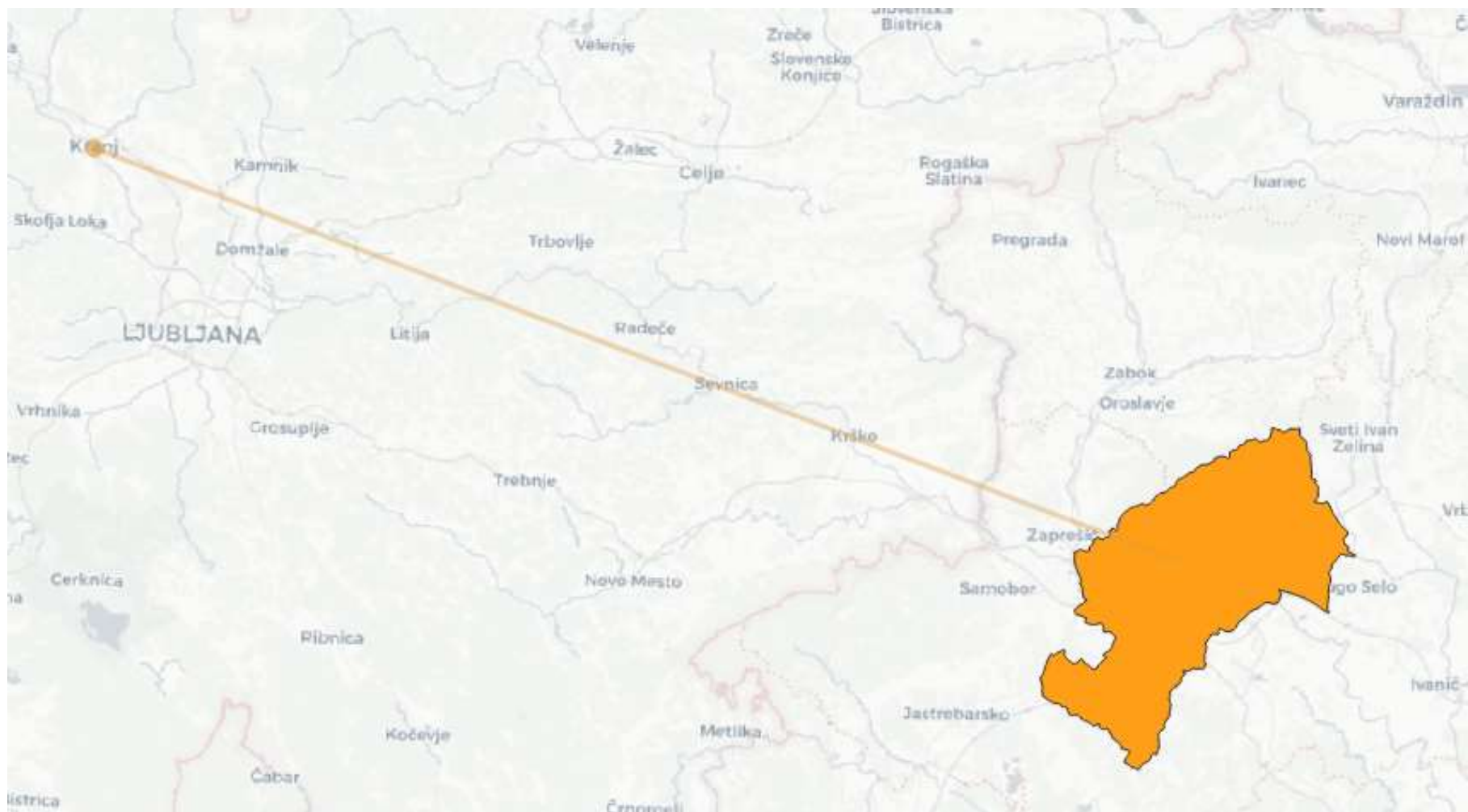
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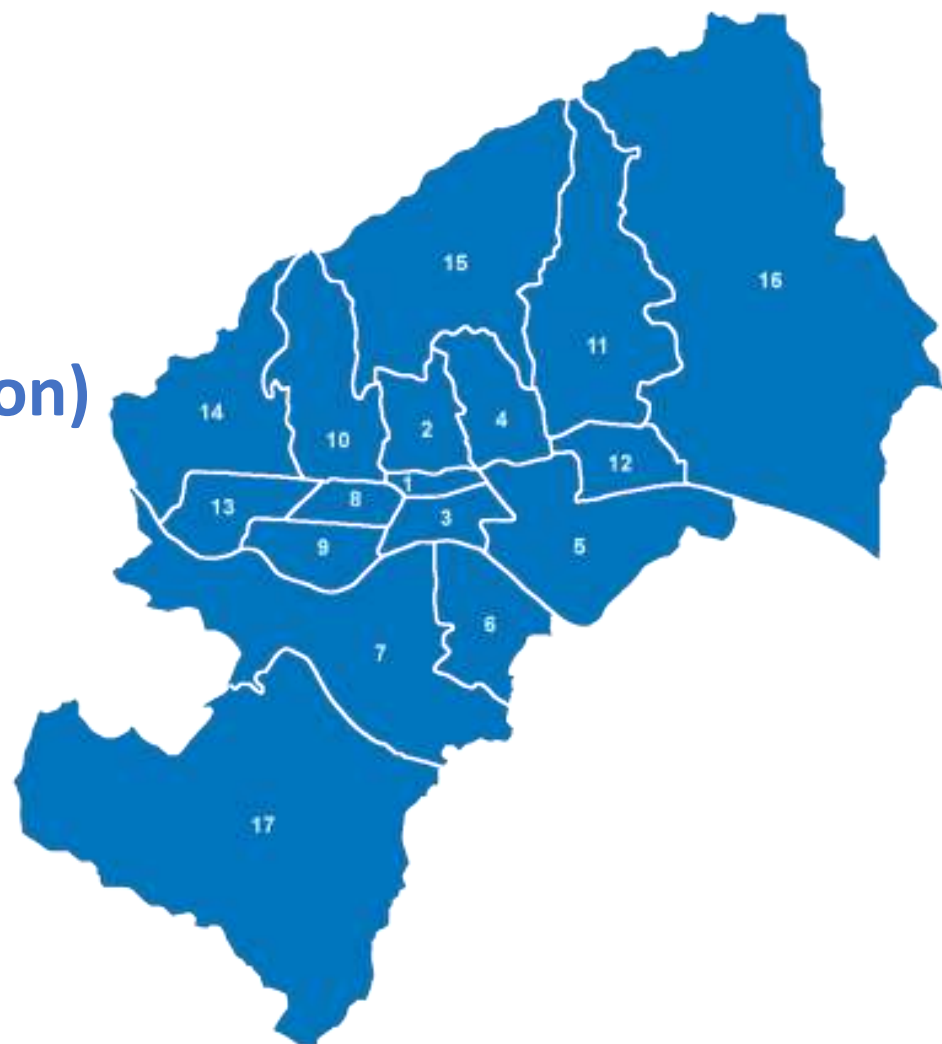
zavod za
prostorno
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grada
zagreba

Zagreb



Zagreb in Croatian Context (2021. Census)

- **Croatian Population:**
 - 3 871 833
- **Total Population:**
 - 790 017 (20% of Croatian Population)
- **Number of City Districts:**
 - 17
- **Number of Croatian municipalities:**
 - 555



Zagreb in Croatian Context (2021. Census)

CITIES	
City	Population
Zagreb	790 017
Split	160 577
Rijeka	107 964
Osijek	96 313
Zadar	70 779
Velika Gorica	61 075
Pula	52 220
Slavonski Brod	49 891
Karlovac	49 377
Varaždin	43 782

ZAGREB DISTRICTS	
Sesvete	70 800
Trešnjevka – jug	65 324
Novi Zagreb – zapad	63 917
Gornja Dubrava	58 255
Novi Zagreb – istok	55 898
Stenjevec	53 862
Peščenica – Žitnjak	53 023
Trešnjevka – sjever	52 974
Maksimir	47 356
Podsused – Vrapče	44 910
Trnje	40 539
Črnomerec	38 084
Donja Dubrava	33 537
Donji Grad	31 209
Gornji Grad – Medveščak	26 423
Podsljeme	18 974
Brezovica	12 046

Zagreb in Croatian Context (2021. Census)

Combined list	
Split	160577
Rijeka	107964
Osijek	96313
Sesvete	70800
Zadar	70779
Trešnjevka – jug	65324
Novi Zagreb – zapad	63917
Velika Gorica	61075
Gornja Dubrava	58255
Novi Zagreb – istok	55 898

- On the list of the 10 most populous places in Croatia, 5 are city districts of Zagreb, highlighting Zagreb's importance as an urban center with significant demographic relevance.

Need for detailed analysis

- This table clearly highlights that five city districts rank among the top 10 when combining the population of Croatian cities and.
- This underscores the demographic significance of Zagreb's districts, showing that **their population sizes are comparable to or even surpass many Croatian cities.**
- The fact that city districts make up half of the top 10 list emphasizes the need for targeted and localized analysis.

Data

- Data is aggregated from Croatian Bureau of Statistics, into 4 key areas with its variables:
 - **Household: 5**
 - Size, family vs. non family households,...
 - **Dwellings : 5**
 - Occupied and unoccupied, ownership details,...
 - **Population: 9**
 - Total, old, young, reproductive women, working population...
 - **Migration: 5**
 - Living in same settlement since birth, migrations, etc..

Key analysis

- **Population Dynamics:** These variables allow to study local population aging, density disparities, and shifts in settlement patterns.
- **Housing Analysis:** The data on occupied and unoccupied dwellings and ownership patterns is critical for exploring urban housing issues.
- **Migration Insights:** Data on internal and international migration provides a basis to explore patterns of movement between districts
- **Spatial Inequalities:** Differences between central and peripheral areas, a key point in your abstract, can be quantified

Methodology Framework

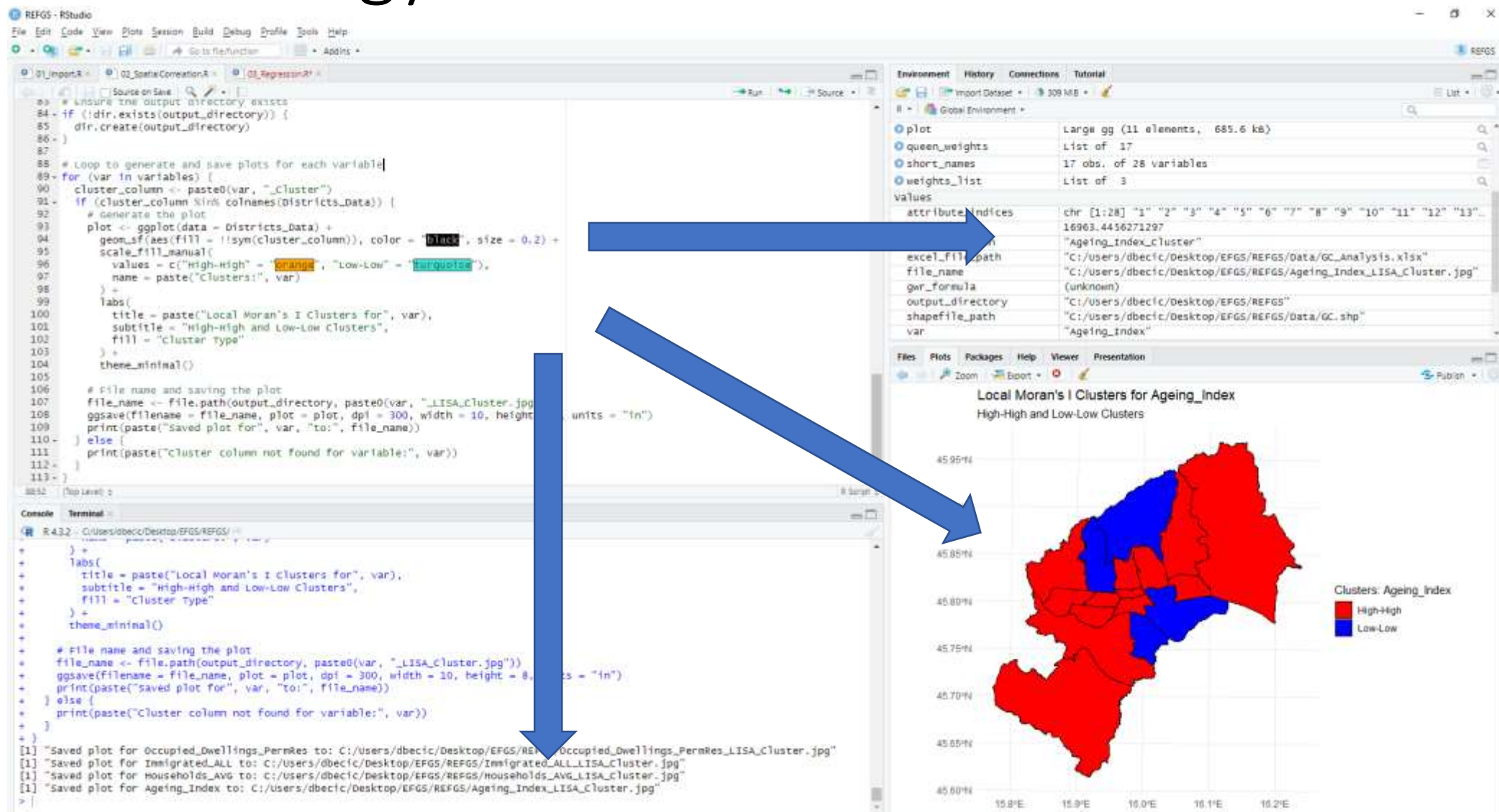
- **Data Processing and Descriptive Statistical Analysis**
 - R programming language with libraries for data modeling
- **Exploratory Spatial Data Analysis (ESDA)**
 - Global Moran's I, Local Moran's I (LISA), Getis-Ord G_i^*
- **Predictive Modelling**
 - Geographically Weighted Regression (GWR)
- **Geovisualization**



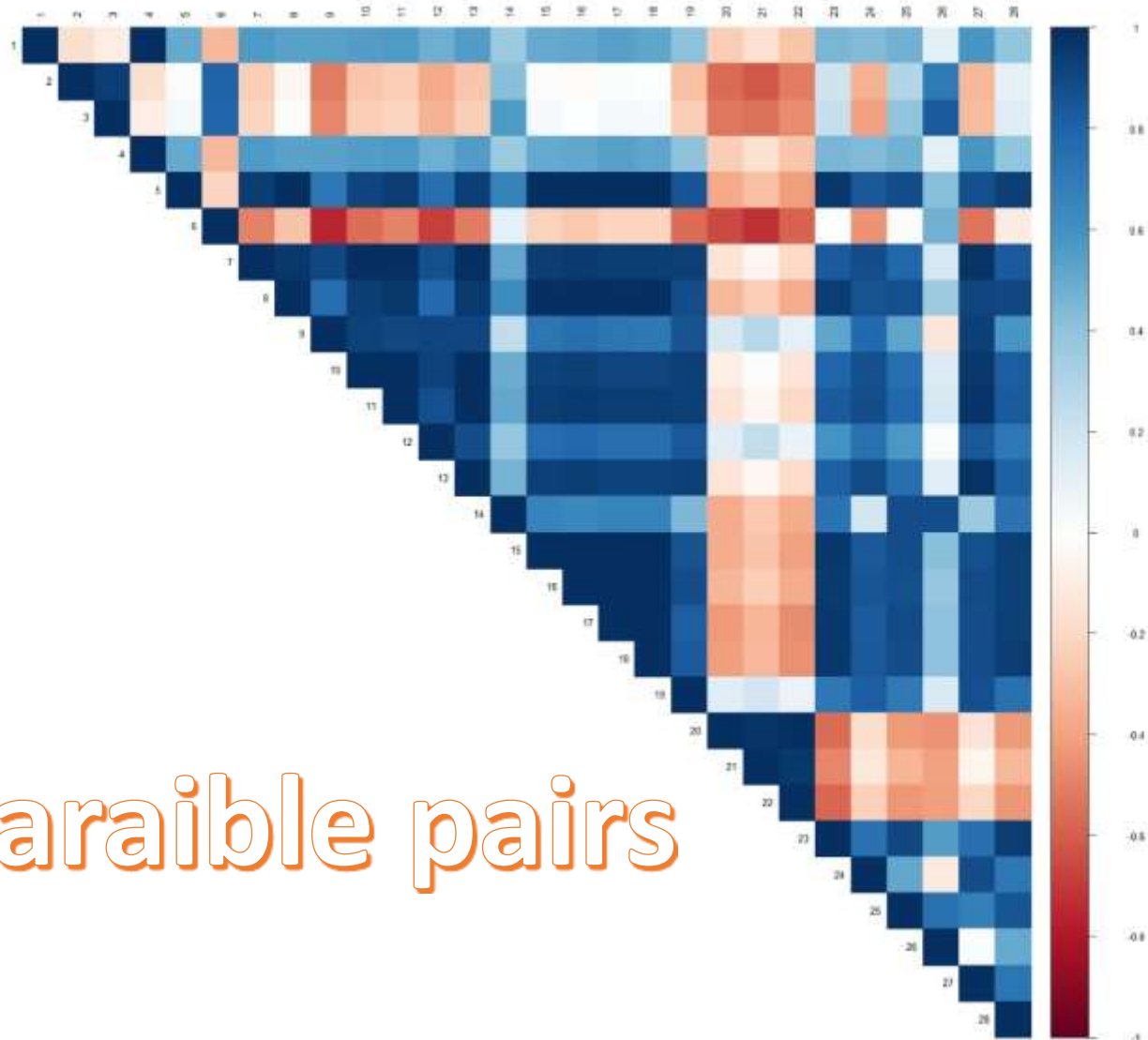
Advantages of R for Spatial Analysis

- **Reproducibility:** Every step, is documented in the code, ensuring transparency and ease of validation.
- **Customizability:** Complex spatial models are implemented and visualized in ways that are hard to replicate in standard GIS platforms.
- **Efficiency:** By automating repetitive tasks, R saves time and reduces errors, making it ideal for projects requiring iterative exploration of spatial data.
- **Scalability:** Scripts can handle large datasets and be modified for different spatial contexts without starting over, unlike many GIS tools that may require reconfiguration for each dataset.

Methodology Framework



Correlation Matrix



276 of variable pairs

Correlations

- **Positive Correlations:**
 - **Average Age & Occupied Dwellings (~0.85):**
 - Older populations prefer stable housing.
 - **International Immigration & Working Population (~0.88):**
 - International migrants significantly contribute to the workforce.
 - **Private Ownership & Family Households (~0.93):**
 - Private ownership is linked to family housing preferences.
 - **Household Members & Population (~0.95):**
 - More household members correlate with larger populations.
 - **Young Population & Family Households (~0.89):**
 - Youth-dominated areas often have more family households.

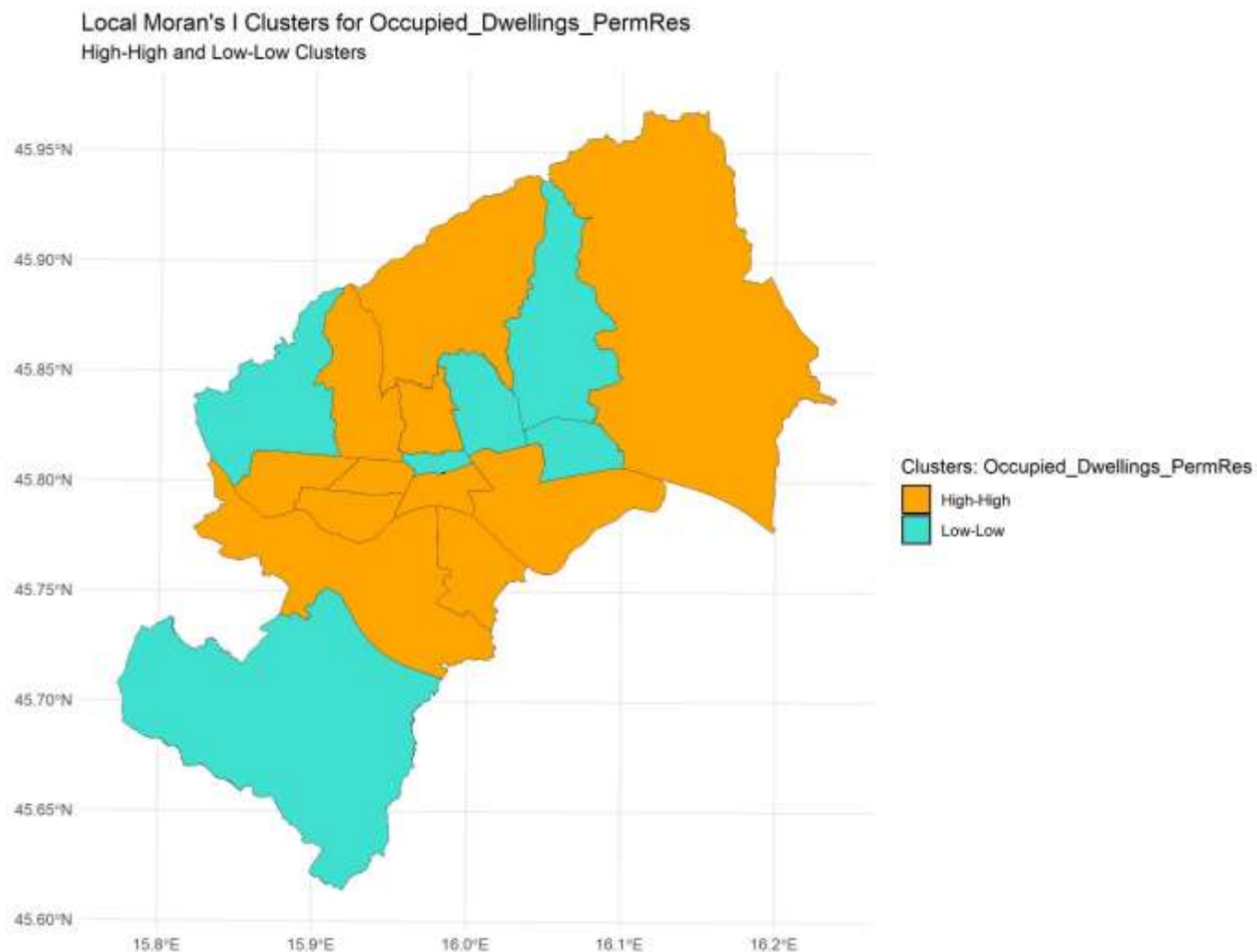
Correlations

- **Negative Correlations**

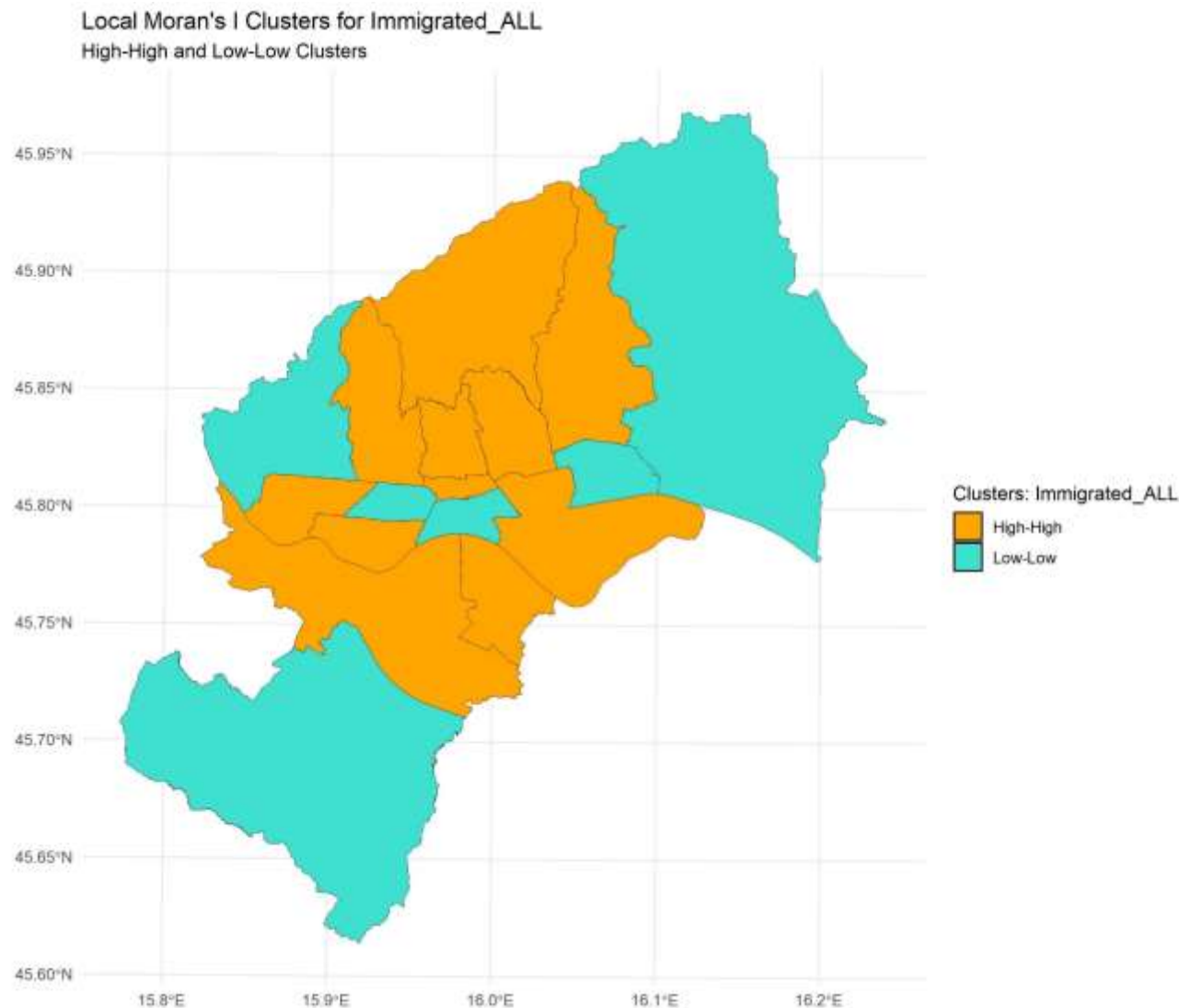
- **Aging Index & Youth Population (~ -0.72):**
 - „Older” districts have fewer young residents.
- **Local Migration & Unoccupied Dwellings (~ -0.68):**
 - Local migration reduces unoccupied housing.
- **Working Population & Aging Index (~ -0.70):**
 - Working districts attract younger populations.
- **Immigrated All & Unoccupied Dwellings (~ -0.65):**
 - High immigration correlates with lower unoccupied housing.
- **Population Density & Age Coefficient (~ -0.60):**
 - Densely populated districts have younger age profiles.

Spatial Context

- Central districts display low of occupied dwellings

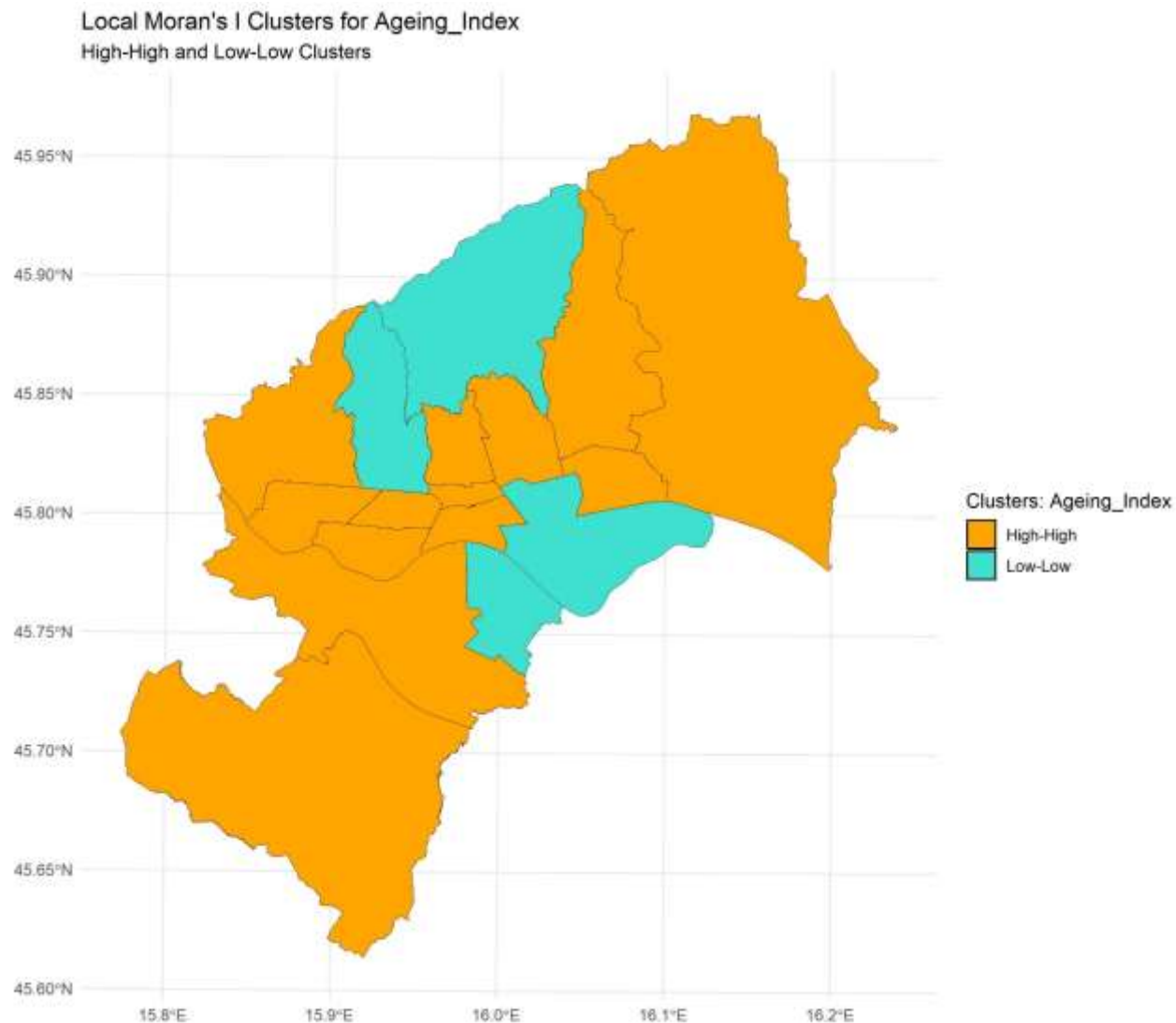


Spatial Context



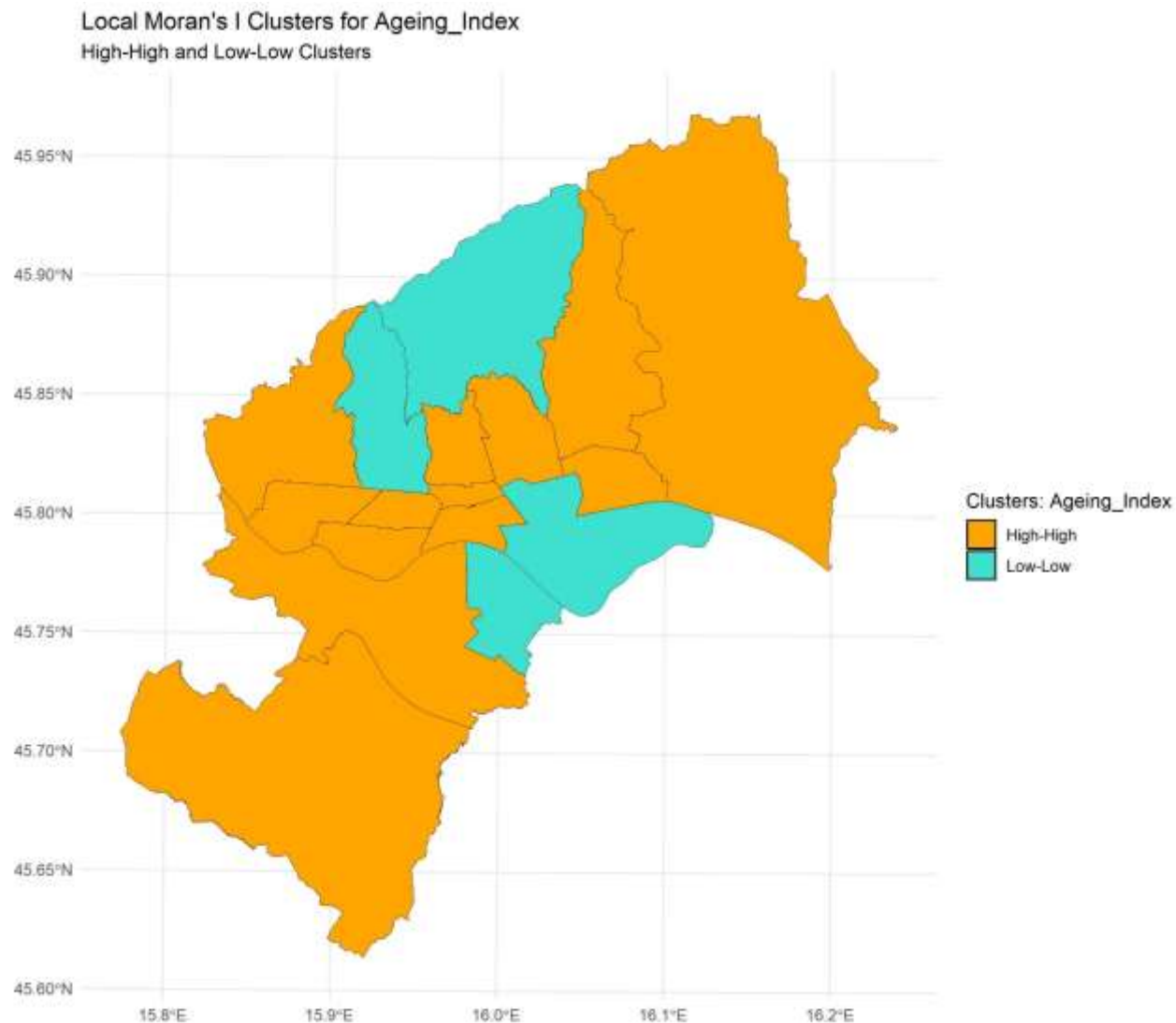
- As for migration insights, most central and outer districts display low clustering

Spatial Context



- Almost every city districts fall into high cluster

Spatial Context



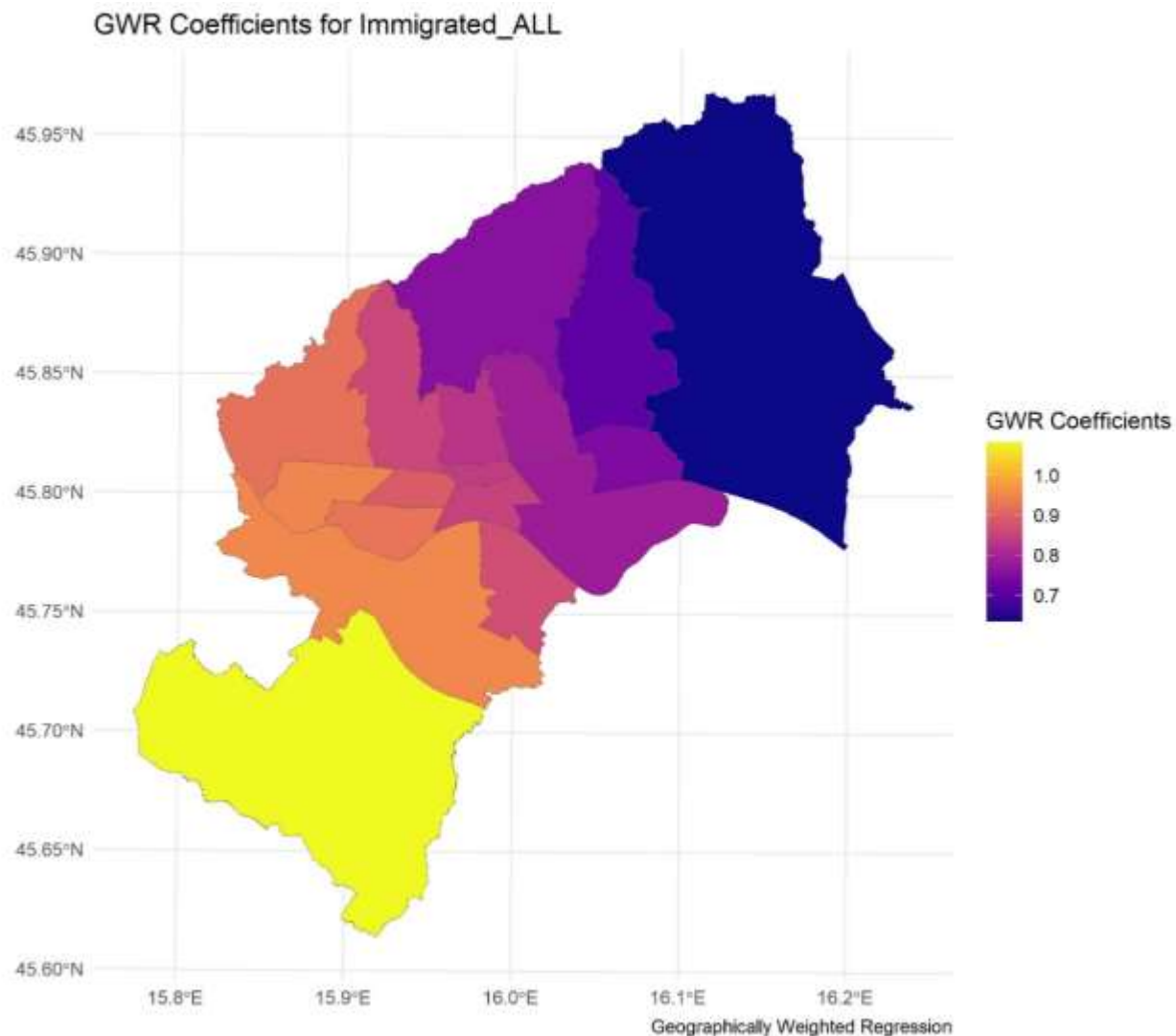
- Almost every city districts fall into high cluster

Spatial Context

```
<
> # Run the GWR model
> gwr_model <- gwr(gwr_formula, data = Districts_Data_sp, bandwidth = bandwidth)
>
> # Print GWR results
> print(gwr_model)
Call:
gwr(formula = gwr_formula, data = Districts_Data_sp, bandwidth = bandwidth)
Kernel function: gwr.Gauss
Fixed bandwidth: 16963.45
Summary of GWR coefficient estimates at data points:
              Min.    1st Qu.    Median    3rd Qu.    Max.    Global
X.Intercept.  7.0111e+03  9.5845e+03  1.0485e+04  1.1347e+04  1.3197e+04 10817.0072
Immigrated_ALL 6.3516e-01  7.8495e-01  8.5055e-01  9.2142e-01  1.0825e+00   0.7964
```

- Immigration impacts housing occupancy differently across districts, with a median increase of **0.85** occupied dwellings per immigrant, but this varies from 0.64 to 1.08 depending on the district.

Spatial Context



- Coefficient around 0.63 = blue areas
- Coefficient around 1.08 = yellow areas
- Correlation between GWR coefficients and unoccupied permanent residences: -0.15
- In areas where immigration strongly impacts occupied dwellings (there might be fewer unoccupied homes)

Contribution

- **Methodology:**

- Combines ESDA and GWR in R, offering deeper insights into spatial patterns compared to standard GIS tools. Fully reproducible and adaptable for other datasets and regions.

- **Spatially-Relevant Insights:**

- The analysis reveals clear spatial disparities in housing occupancy and the impacts of immigration across Zagreb's districts.

- **Scalable Approach:**

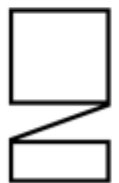
- R allows for seamless integration of advanced spatial statistics (e.g., Moran's I, GWR) and the creation of publication-ready visualizations directly from the analysis workflow.

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Thank you!

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