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SUPPLEMENTARY INFORMATION

Effects of demand estimates on the evaluation and optimality of service centre locations

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TABLE OF CONTENTS

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1. Quality of the OSM road network

To the best of our knowledge, currently there is no study that evaluates a quality of OSM road network for the area of the Slovak Republic. For the analyses presented in the main paper, the information about the travel times between pairs of DPs is crucial. Hence, when evaluating the quality of the road network, we can restrict ourselves only to this aspect. Here, we compare OSM with HERE Maps (previously known as OVI Maps or Nokia Maps, www.here.com). HERE Maps enables to obtain the shortest paths and travel times between pairs of road network vertices.

It is not publicly known how the travel times are estimated by HERE Maps. Therefore, we decided to compare lengths of the shortest paths. For each selected district (see Table 1 of the main paper), we randomly selected 1000 different pairs of the road network vertices. Origin and destination vertices were always chosen from two different municipalities. We calculated the shortest path length between them using OSM data. Using the geographical coordinates, we entered both nodes into HERE Maps and we calculated the shortest path. Average values of the absolute differences between lengths of both shortest paths are displayed in Figure 1.

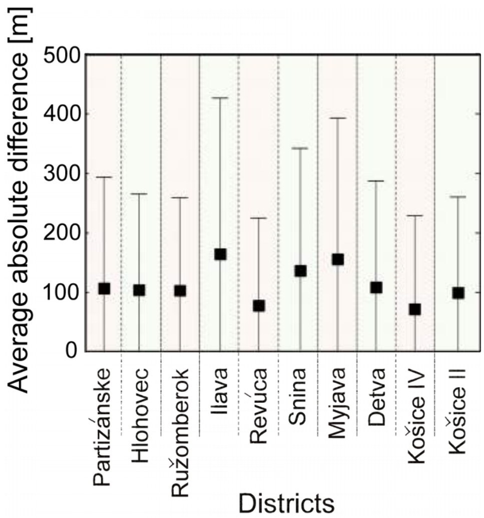

Figure 1. Average of absolute differences between lengths of shortest paths calculated from OSM road network and obtained from HERE Maps. Average is taken over 1000 node pairs in each district. Error bars are reflecting the standard deviation around the average.

The average absolute difference is for all selected districts less than 180 meters and in the majority of districts it is within 110 meters. Because we generated data models considering square cells 100×100 metres, we conclude that the level of agreement between OSM and HERE Maps is sufficient for the purposes of this paper.

It should be also noted that existing differences are not inevitably caused by errors in OSM data. When analysing the cases with the largest absolute differences, we identified two classes of problems causing differences between paths. The first source of inconsistencies is in the routing algorithm. HERE Maps uses an advanced routing algorithm that can, to some extent, consider the traffic rules. We used the classical Dijkstra algorithm on the OSM road network, which allows changing the direction when it is permitted by the directed graph that represents the road network. The second source of differences is in the quality of the OSM and HERE Maps road networks. Lower quality of road networks we find in rural areas. We found many small villages that differ in the completeness of the road network. While some areas are better covered in OSM, some other are better in HERE Maps. Therefore, it is hard to conclude clearly, which road network is more complete.

Although it was very rare, we also found some disagreements in the road segment classes in rural areas. We identified several apparent problems in both data sets. Occasionally, a missing minor road segment (forest, dirty or field road) was leading to a large difference in the shortest paths length. We identified five situations of missing minor road segment in HERE Maps and three missing minor road segments in OSM data leading to the absolute difference larger than 1 km. We eliminated such cases from the analysis as outliers, because we do not expect emergency public systems vehicles using such road segments and thus these cases would lead to misleading distortions in the results.

2. Comparison of Residential and Ambient Population Grids

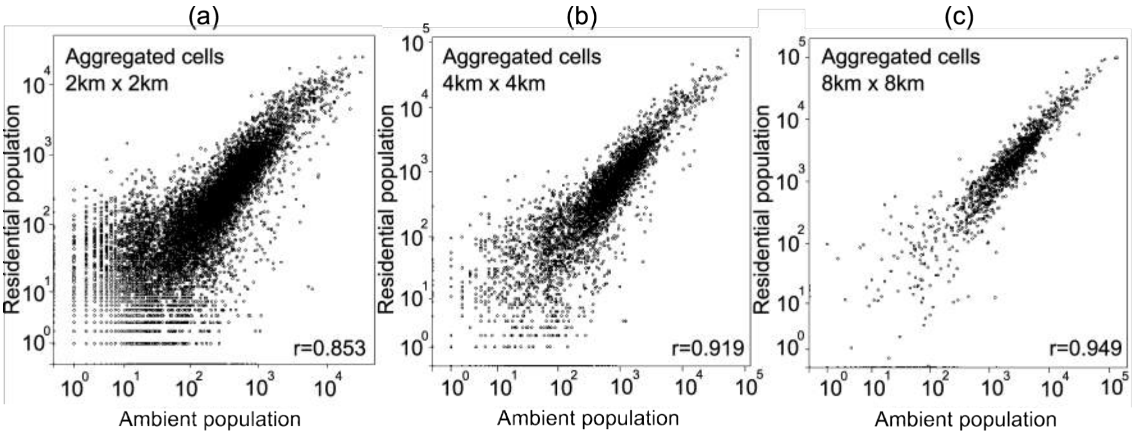

Figure 2. Scatter plot of the cell population comparing AP and RP grids for the area of the Slovak Republic using the resolution of (a) 2×2 km, (b) 4×4 km and (c) 8×8 km. Pearson product-moment correlation coefficient between population values attributed to individual grid cells we denote as *r*.

3. Complete Results of Numerical Experiments

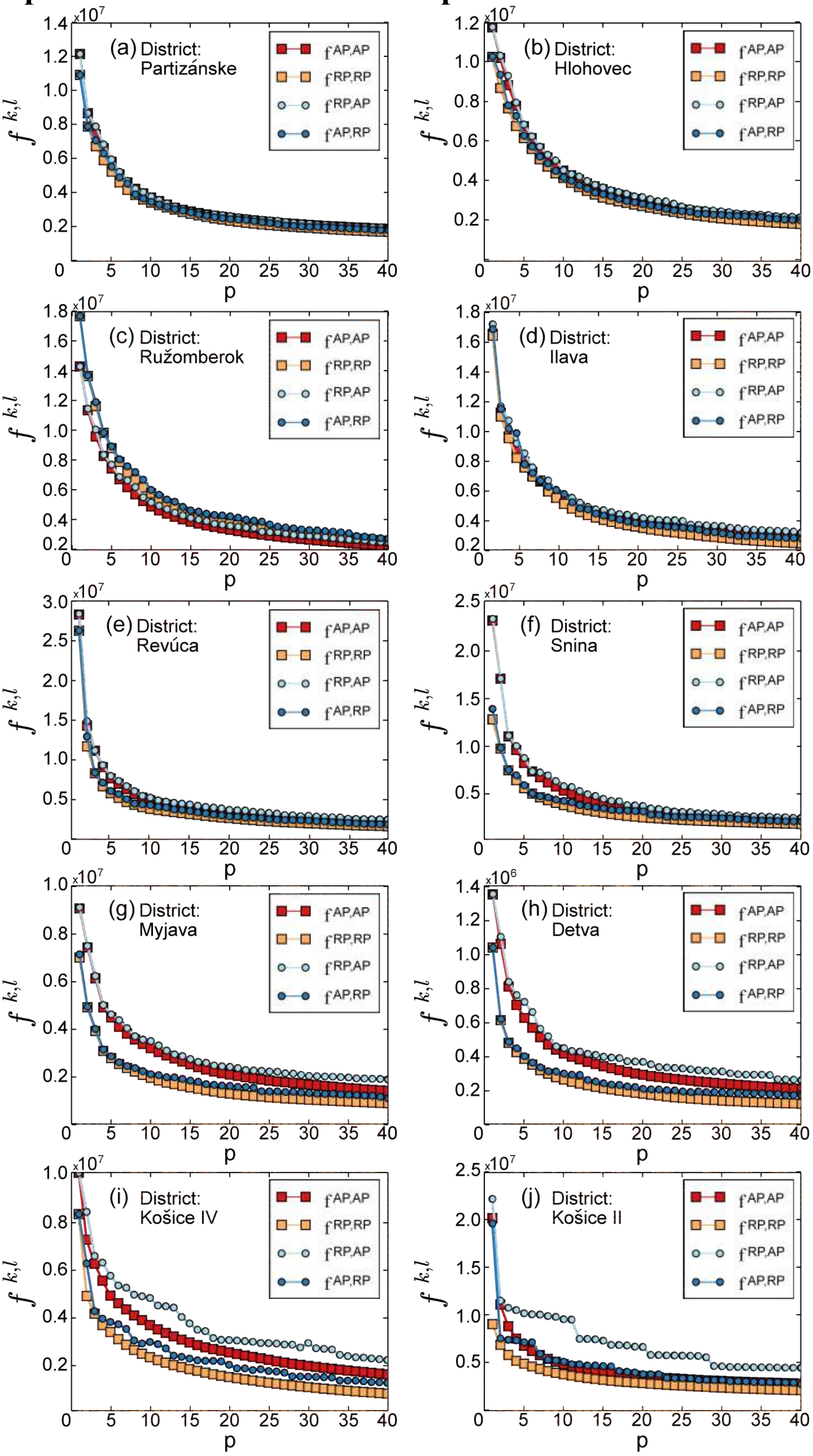

Figure 3. The sum of weighted travel times in seconds from DPs to the closest service centre (objective function value) as a function of the number of located service centres p. More detailed information about selected districts is given in Table 1 of the main paper.

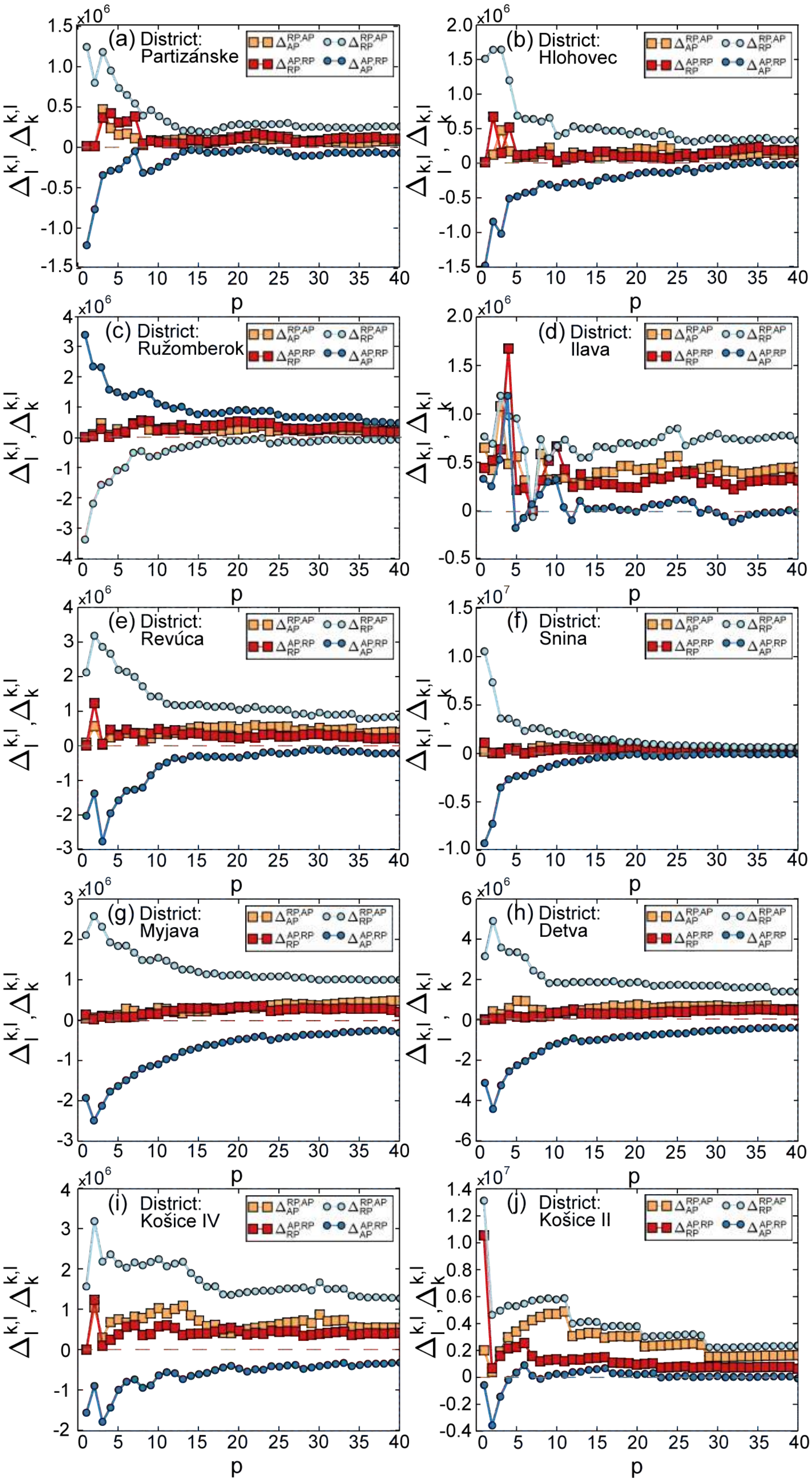

Figure 4. Absolute location and evaluation errors measured for ten selected districts, caused by the interchange of population grids as a function of the number of located service centres p. More detailed information about selected districts is given in Table 1 of the main paper.

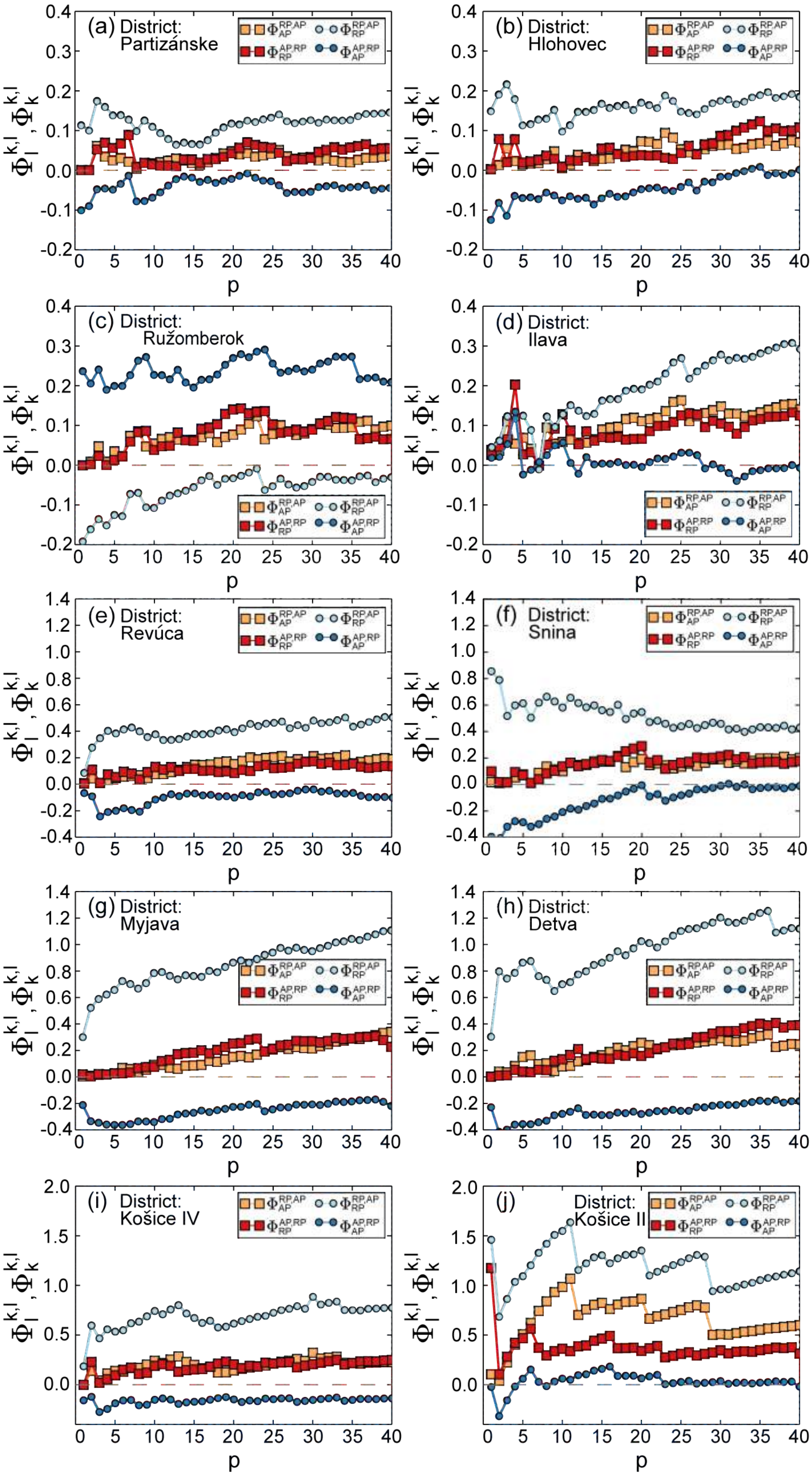

Figure 5. Relative location and evaluation errors measured for ten selected districts, caused by the interchange of population grids as a function of the number of located service centres *p*. More detailed information about selected districts is given in Table 1 of the main paper.

4. Choropleth maps of Partizánske and Košice II districts

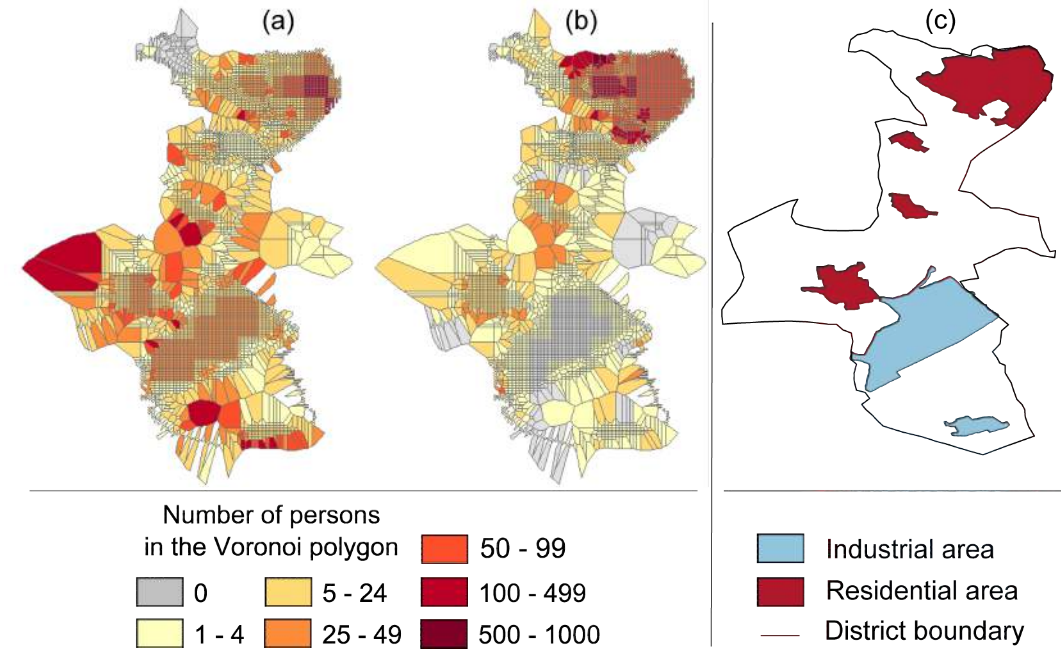

Figure 6. Choropleth map of the population of the district Košice II that is associated to the Voronoi polygons that are generated from the positions of DPs. (a) AP population. (b) RP population. (c) Illustration of residential and industrial areas (source: CORINE Land Cover 2006).

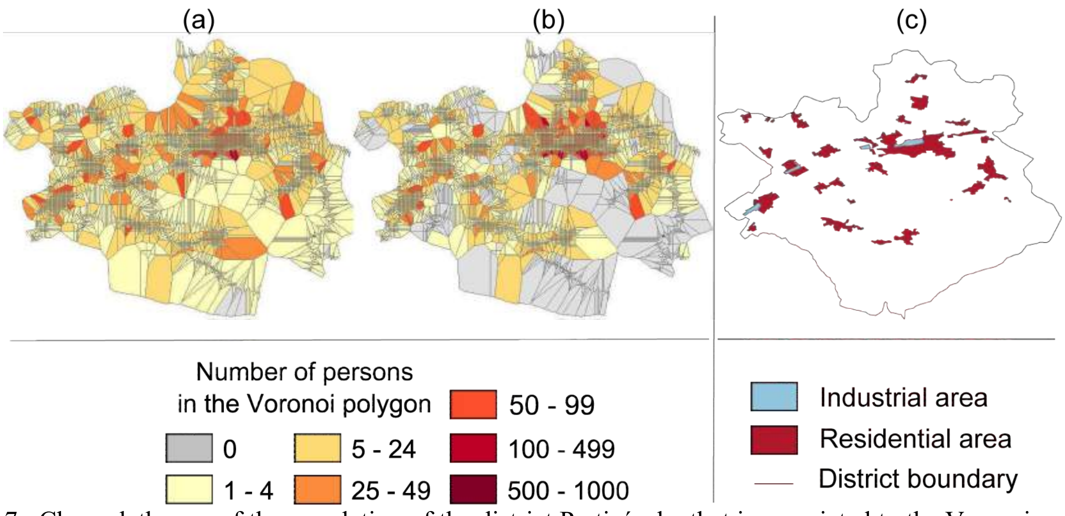

Figure 7. Choropleth map of the population of the district Partizánske that is associated to the Voronoi polygons that are generated from the positions of DPs. (a) AP population. (b) RP population. (c) Illustration of residential and industrial areas (source: CORINE Land Cover 2006).

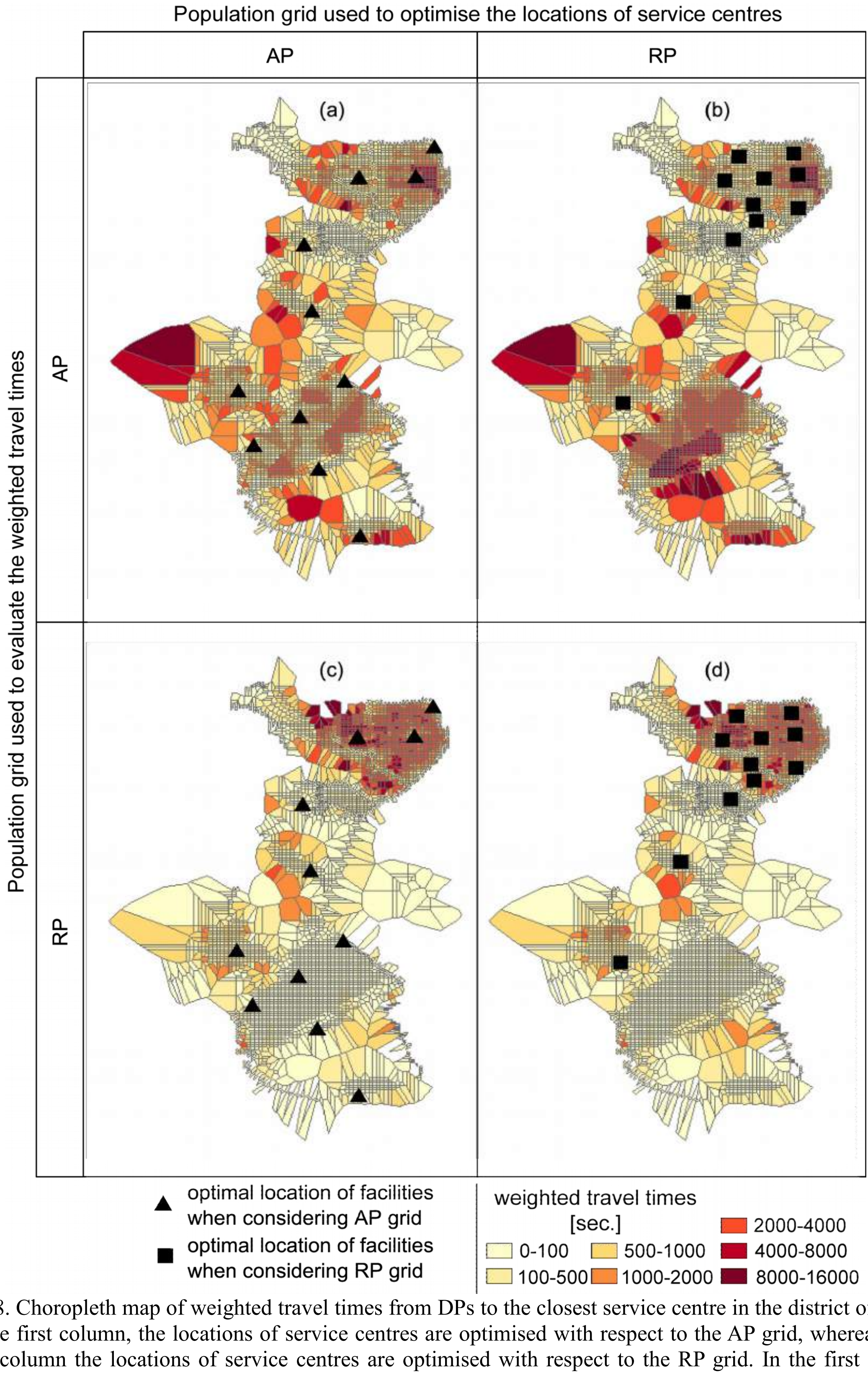

Figure 8. Choropleth map of weighted travel times from DPs to the closest service centre in the district of Košice II. In the first column, the locations of service centres are optimised with respect to the AP grid, whereas in the second column the locations of service centres are optimised with respect to the RP grid. In the first row, we evaluate the shortest travel times on the road network between DPs and closest service centres considering AP grid, while in the second row we evaluate the shortest travel times on the road network between DPs and closest service centres considering RP grid.

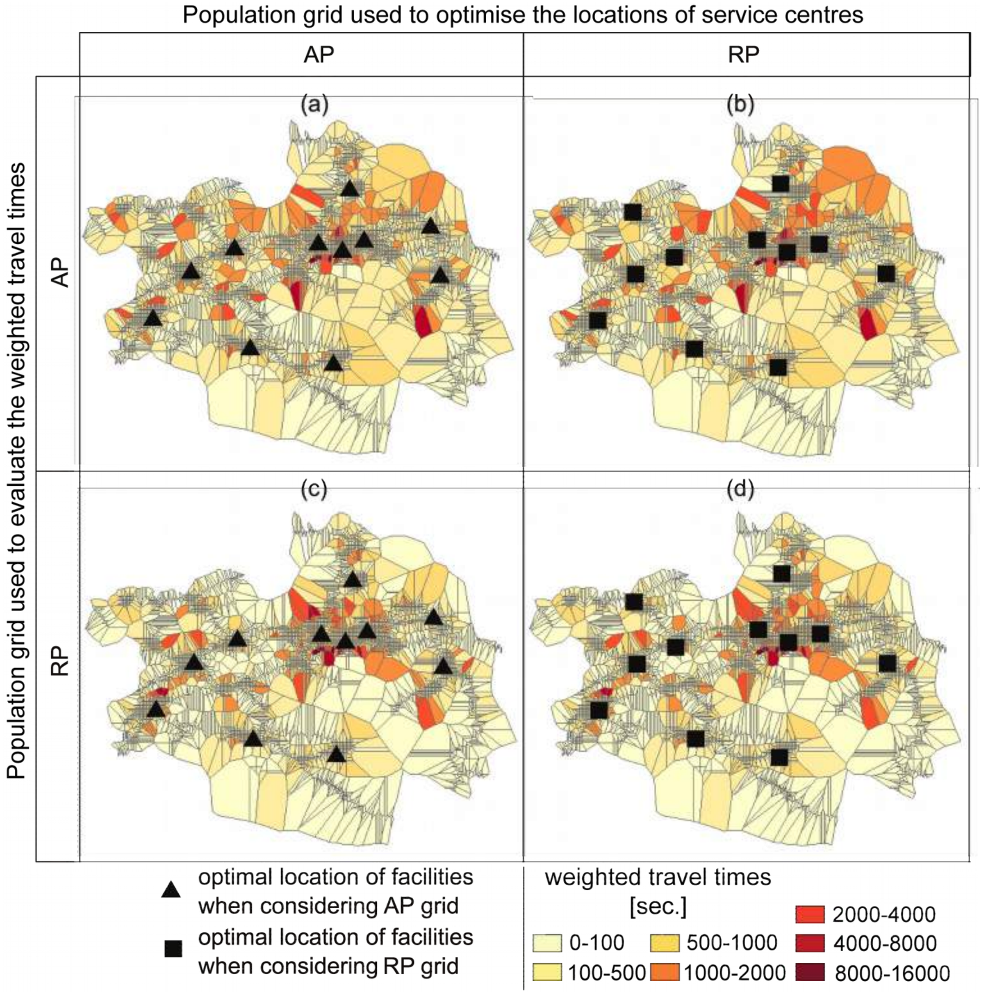

Figure 9. Choropleth map of weighted travel times from DPs to the closest service centre in the district of Partizánske. In the first column, the locations of service centres are optimized with respect to the AP grid, whereas in the second column the locations of service centres are optimized with respect to the RP grid. In the first row, we evaluate the shortest travel times on the road network between DPs and closest service centres considering AP grid, while in the second row we evaluate the the shortest travel times on the road network between DPs and closest service centres considering RP grid.

Acknowledgement

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