Geography Extended Essay

Comparative Study of the Availability of Public Services in Districts of Warsaw

Research Question: What is the pattern of availability of public services, measured by access to healthcare, education and public transport in the districts of Warsaw, and does this pattern correlate with the average prices of real-estate properties?

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1. Introduction

The aim of this work is to obtain an aggregated and universal index, allowing to compare the development and availability of public services between the districts of Warsaw. Furthermore, the study will also verify if the created index is corresponding to the economic perception, expressed by the average price of real-estate properties.

1.1. Research Question

What is the pattern of availability of public services, measured by access to healthcare, education and public transport in the districts of Warsaw, and does this pattern correlate with the average prices of real-estate properties?

1.2. Geographical Context

1.2.1 Human Development Index

The Human Development Index is a composite indicator used to measure the quality of life in countries. It was first introduced in 1990 by the United Nations Development Programme (Codrington, 2013, p.75). As a composite indicator of development, the HDI combines several measures of development into a single figure, ranging from 0 to 1. This index comprises three dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living (UNDP, 2017). The first dimension is measured by the life expectancy at birth of a given country. The education dimension is expressed by both mean years of schooling for adults over 25 years old and expected years of schooling for children entering school age. The last dimension, a decent standard of living is assessed by gross national income per capita, adjusted for purchasing power parity.

In 1997, an interesting attempt at an adaptation of the Human Development Index took place. Stephen J. Agostini and Sandra J. Richardson have expanded the usage of the index to compare the quality of life between different cities (Agostini, Richardson, 1997). In my work, however, I will attempt to create an index on an inter-district level, comparing the quality of life between the districts of one city, by assessing the availability of the public services.

1.2.2. Warsaw (area of investigation)

Warsaw is the capital and the largest city of Poland. It is located in the central-east of Poland, in the Mazovian Voivodeship. The city is divided into 18 districts, spread on a total area of 517km² and has a population of 1.7 million inhabitants (GUS, 2017). Warsaw was destroyed in about 80% over the course of World War II (Majewski, 2005). Today it is one of the most dynamic European cities, a cultural and economic hub and a popular tourist destination.

Figure 1: Map of Warsaw and its 18 districts, based on Google Maps.

1.3. Method of investigation

1.3.1. Public services availability index concept

My concept is to compare the availability of public services in the districts of Warsaw by means of a universal indicator. The indicator itself will be similar to HDI in the method of calculation. However, the inter-district index will concern some different dimensions. Henceforth, the index will be referred to as Urban Services Availability Index (USAI).

The USAI compares the availability of public services within districts of a city in three dimensions: access to healthcare, access to education and availability of public transport. The reason for these three dimensions to be chosen is because I believe that these three aspects of urban services are the most crucial to decide which district has the highest quality of life. Being able to reach a medical centre fast, have a short way to school, all utilizing reliable public transportation, should be the essential criteria in choosing a place to live. When created, this indicator will allow to compare these criteria between the district of a city and point out which districts have the largest capacity of certain public services. The index measures the availability of public services within a district by means of infrastructures and services that can be accessible to every citizen. That is the reason why only public hospitals, clinics and schools are taken into account while calculating the index.

The first USAI calculation will concern the absolute capacities of districts in these three dimensions, showing how the services are spread among the districts. The created index will be referred to as „absolute USAI" The second USAI calculation will show the relative capacities of the districts, as it will use the total scores (absolute capacities) divided by the number of people living in a given district. This presentation will show how well a given district public services support the inhabitants, and whether this amount is sufficient or not. This index will be referred to as the „relative USAI".

1.3.2. Specific method of investigation

For each dimension, the data will be gathered by means of a scoring system. This means that for example a primary school will be awarded a higher number of points that a preschool, or that a regular bus line will be worth more than a night line, which will also be corresponded by the points. This would allow the measurements to have a fair scale as a multi-ward hospital is much more significant for the district than a small health clinic. That is why every dimension will follow the specific grading rules which are described in detail below.

Access to healthcare:

For this dimension, the Polish National Health Fund database was used to collect the data (NFZ, n.d.). I assumed that all the entries in this database have an agreement with the Fund and therefore are accessible publicly. I also assumed that the database is complete, and contains every public medical centre in Warsaw. The database features three types of medical facilities: the basic healthcare facilities, specialized healthcare facilities, and facilities with 24-hour care, i.e. hospitals. It contains a search engine with which it is possible to search for these facilities in every district of Warsaw separately. The entries in the database for the specialised facilities and hospitals were listed separately for every hospital ward or a consulting office. Therefore a single hospital had many entries as it possesses many wards. The scoring based on counting the entries for each of the three categories, for all 18 districts. For entry in the first category (basic care facilities), one point was awarded, whereas, for the second category (specialized facilities), two points were given. For 24-hour care facilities, three points were awarded for each entry. This allowed a multi-ward hospital to be worth significantly more points than a basic health centre.

Access to education:

The database of the Bureau of education of the Warsaw city hall was used while collecting the data for this dimension (Urząd m.st. Warszawy Biuro Edukacji, 2017). It contained a list of preschools, primary schools and high schools in Warsaw. I assumed that the database is complete and contains every public educational facility of the three types that are being investigated. Based on this database, preschools, primary and high school entries were filtered for every district separately. Based on the significance and the level of complexity education and the abundance, the schools were awarded points in this order: preschools - one point each, primary schools - two points each, high schools - three points each. The preschools, being the most abundant in Warsaw and concerning the lowest level of education were awarded the least points, whereas high schools, being least abundant from the three types, as well as presenting the highest level of education, were awarded the largest number of points.

Availability of public transportation

For measuring the availability of transport, the official site of the Public Transport Authority (ZTM) was used (ZTM, n.d.). From the list of all bus and trams stops of a district, every stop name has been put into a spreadsheet with a specified number of lines of public transport. In the spreadsheet for every stop name, the number of tram lines, regular bus lines and lines „for request" or night lines was specified. The line „for request" means that a bus does not regularly stops at this particular stop, but only when it is requested, for example by pressing a button in the bus or hand signalling while on the stop, by a person willing to ride the bus.

For all the categories listed above, the scoring system was applied. The scoring guidelines were set by an estimated number of people a given type of public transport can jet within

one hour. The most common tram in Warsaw, „PESA Swing" can take up to 200 people at once (Tramwaje Warszawskie, 2015). Riding about six times an hour this gives a total number of 1200 people per hour. The most abundant bus in Warsaw, Solaris Urbino 18 can take up to 176 people at once, and riding about five times an hour, gives a total of 880 people per hour („Solaris Urbino 18", 2017). A night line in Warsaw rides approximately once an hour, yielding five times less than a regular bus. A suburban train (SKM) can jet about 650 people at one go, and given the trains ride every 15 minutes, this gives about 2600 people an hour (SKM Sp. z o. o., 2007). The subway rides every 2.5 minutes giving a total of 24 rides an hour. A subway train can fit about 1500 people, which gives a total number of 36000 people (Metro Warszawskie Sp. z.o.o., n.d.). Basing solely on these capacities, the scoring guidelines are as follows: A regular bus line being worth 1 point, determines the value of a night line, which rides five times less, giving a sore of 0.2 points. A tram line can carry about 50% more people an hour. Therefore a single line is worth 1.5 points. A suburban train carries about twice the number of people an hour than the tram, so it is awarded 3 points. A subway, jetting 40 times more people an hour than a regular bus, is, therefore, worth 40 points.

1.3.3. Calculation of the USAI

The Urban Services Availability Index method of calculation is similar to the method of calculating the HDI. Firstly the dimension indices have to be calculated, as they are the constituent indices of the USAI. As in the HDI calculation, the minimum and maximum values for every dimension have to be determined (UNDP, 2017). The minimum value for all three indices will be zero, as it will then assume that there is no health centre, school or public transportation in a given district. The maximum value cannot be determined from above; it is dependent on the results. Therefore the maximum value for a particular dimension will be the highest number of points scored by a district.

Having both values determined, the calculation of the dimension indices will be performed according to the formula (UNDP, 2017):

$$\text{Dimension index} = \frac{\text{actual value-minimum value}}{\text{maximum value-minimum value}}$$

Once the dimension indices are calculated, the composite index: USAI will be calculated by a geometric mean of the three dimension indices, as in the HDI calculation (UNDP, 2017). The formula is, therefore, the following (UNDP, 2017):

$$USAI = \sqrt[3]{(I_{Healthcare} \times I_{Education} \times I_{Transportation})}$$

2. Analysis

2.1. Data presentation and analysis

The absolute sums of collected points for all three dimensions were calculated and are present in the table below.

Table 1: Absolute sums of points gathered by every district in the three dimensions.

District	Healthcare sum	Education sum	Transportation sum
Bemowo	52	49	243,4
Białołęka	57	45	320,5
Bielany	206	107	445,4
Mokotów	536	212	775
Ochota	454	86	343
Praga Południe	410	149	589,3
Praga Północ	199	70	342,2
Rembertów	44	20	89,8
Śródmieście	494	179	1090,2
Targówek	195	81	343,6
Ursus	102	32	107,8
Ursynów	240	62	413,5
Wawer	289	58	262,4
Wesoła	30	17	83,6
Wilanów	46	19	80,6
Włochy	40	34	186,9
Wola	360	174	479
Żoliborz	154	72	226,2

From the absolute sums, it can be seen that there are great differences between the districts. For example in the sums for the healthcare dimension, Śródmieście district gathered 494 points, whereas Wesoła only 30, which is about 15 times less. This shows how different the districts are regarding absolute capacity and availability of public services. The differences are present in every dimension. However, there are also many districts with comparable sums, like Targówek and Praga Północ in the healthcare dimension, or Ursynów and Wawer in the Education dimension.

2.1.1. USAI for the absolute capacities of districts

To calculate the USAI index, the component, dimension indices have to be calculated as the component indicators of the composite index. To calculate the dimension indices, the minimum and maximum values for all three dimensions have to be determined. As stated in section 1.5., the minimum values are 0. However, the maximum values for the healthcare, education and transportation dimensions are 536, 212 and 1090,2 respectively. Using these values and the formula in section 1.5. the dimension indices for the three dimensions can be calculated. The following table shows the index values:

Table 2: Absolute dimension indices for healthcare, education and transportation, for the districts of Warsaw.

District	Healthcare index	Education index	Transportation index
Bemowo	0,0970	0,231	0,223
Białołęka	0,106	0,212	0,294
Bielany	0,384	0,505	0,409
Mokotów	1,00	1,00	0,711
Ochota	0,847	0,406	0,315
Praga Południe	0,765	0,703	0,541
Praga Północ	0,371	0,330	0,314
Rembertów	0,0821	0,0943	0,0824
Śródmieście	0,922	0,844	1,00
Targówek	0,364	0,382	0,316
Ursus	0,190	0,151	0,0989
Ursynów	0,448	0,292	0,379
Wawer	0,539	0,274	0,241
Wesoła	0,0560	0,0802	0,0767
Wilanów	0,0858	0,0897	0,0739
Włochy	0,0746	0,160	0,171
Wola	0,672	0,821	0,439
Żoliborz	0,287	0,340	0,207

The dimension indices show how the absolute sums of points of a district relate to the highest value. It can be therefore seen that values for districts like Rembertów, Wesoła or Wilanów are just about 8% of the highest value in all the dimensions. In the healthcare index, the districts of Śródmieście and Ochota have the smallest gap to the highest value (held by Mokotów) of 0,922 and 0,847 respectively. In the education index, Śródmieście and Wola districts are the closest in value to Mokotów at 0,844 and 0,821. However, in the transportation index, Śródmieście separates itself in value greatly, as the second highest value for this index is 0,711 of Mokotów, and the next value is merely 0,541 in Praga Południe, where Środmieście has almost twice as many points.

Using the data for the dimension indices and the formula in section 1.5., the composite USAI index was created. The values for the districts are sorted from the highest to lowest value and are present in the table below:

Table 3: Absolute USAI values for the districts of Warsaw

District	Absolute USAI
Śródmieście	0,920
Mokotów	0,892
Praga Południe	0,662
Wola	0,623
Ochota	0,476
Bielany	0,430
Ursynów	0,368
Targówek	0,353
Praga Północ	0,338
Wawer	0,329
Żoliborz	0,273
Białołęka	0,188
Bemowo	0,171
Ursus	0,142
Włochy	0,127
Rembertów	0,0861
Wilanów	0,0828
Wesoła	0,0701

The highest USAI value belongs to Śródmieście (0,920), which is followed closely by Mokotów sitting at 0,892. Districts of Wesoła and Wilanów recorded two lowest scores, being 0,0701 and 0,0828 respectively. What is interesting is that 14 districts recorded a USAI value below 0,500, which can be an account of the dominance of the remaining four districts, especially Śródmieście and Mokotów. In absolute terms, these two districts represent the highest capacity of public services in the city of Warsaw.

In order to see how the values of USAI are spread geographically, over the districts of a city, a map was created, with five different hues of blue representing five different sets of values. The diagram is the following:
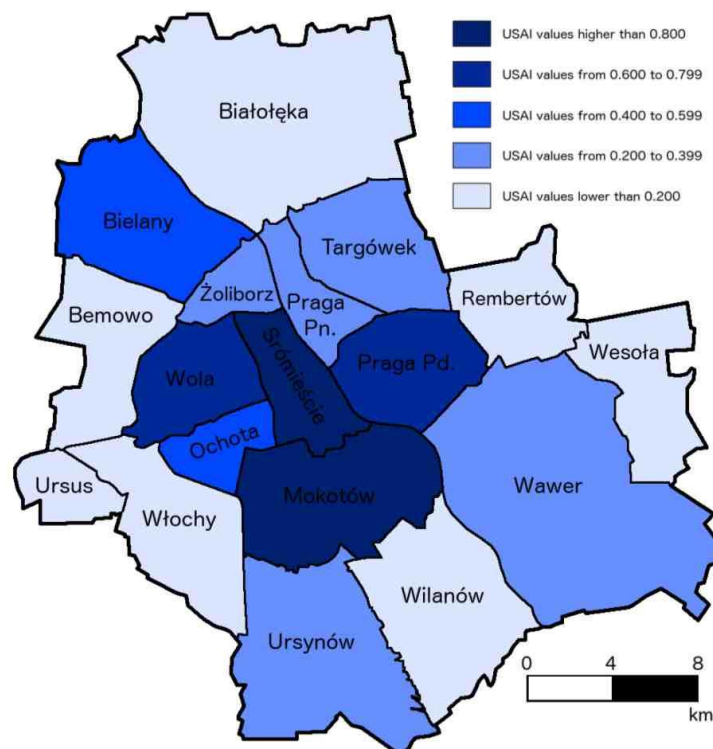

Figure 2: Pattern of the Absolute USAI values in Warsaw

It can be seen on the map, that the districts with the highest values like Śródmieście to Mokotów are concentrated in the centre of the city. All seven lowest values, labelled in light blue colour on the map, are for the peripheral districts of the city. It can be therefore said, that the abundance and availability of public services are higher, the closer we get to the centre of the city. Districts located close to the city centre show higher values of USAI.

2.1.2 USAI for the relative capacities of districts

The absolute capacities of districts, as well as the absolute USAI values, showed the overall abundance of public services in every district. The relative capacities, however, show how well the districts availability of public services supports the people living in it, by dividing the sum of points for a dimension, by the number of inhabitants in a given district. Such a presentation of data is more fair, as the smaller, peripheral districts have fewer people dependent on their capacity than the bigger districts do. The relative capacities will show if the absolute capacities of districts are sufficient, given the number of people relying on its services. The relative sums of points for the three dimensions can, therefore, present new notions. The smaller districts, having low values of USAI in absolute terms, can now show larger values, as the number of people reliant on their services is also smaller. This can lead to equalising the values of the sums of points for the districts and allow them to be expressed in equal and relative terms. The population numbers in each district of Warsaw are taken from this year's report of the Central Office of Statistics, and are present in the table below (GUS, 2017):

Table 4: Population numbers in districts of Warsaw

District	Population
Bemowo	120449
Białołęka	116127
Bielany	131957
Mokotów	217815
Ochota	83592
Praga Południe	178447
Praga Północ	65904
Rembertów	24105
Śródmieście	118301
Targówek	123535
Ursus	58233
Ursynów	149843
Wawer	74932
Wesoła	24811
Wilanów	35170
Włochy	41423
Wola	138508
Żoliborz	50825

With relation to the number of points scored in the dimensions, the population numbers are large, and dividing by such a large number gives a very small quotient. For example, dividing the total score of the district of Bemowo in Healthcare dimension (52) by its population (120449) gives 0,000432. Operation on such small numbers can be prone to errors. Therefore I decided to divide the scores by the number of thousands of inhabitants, with the accuracy to 3 decimal places, so that the population numbers will not be rounded up. So instead of dividing by 41423 in case of Włochy district, all three scores will be divided by 41,423. The relative sums of points for the three dimensions, which are the absolute sums divided by the number of thousands of inhabitants, are present in the table below.

Table 5: Relative dimension indices for healthcare, education and transportation, for the districts of Warsaw.

District	Healthcare sum	Education sum	Transportation sum
Bemowo	0,432	0,407	2,02
Białołęka	0,491	0,388	2,76
Bielany	1,56	0,811	3,38
Mokotów	2,46	0,973	3,56
Ochota	5,43	1,03	4,10
Praga Południe	2,30	0,835	3,30
Praga Północ	3,02	1,06	5,19
Rembertów	1,83	0,830	3,73
Śródmieście	4,18	1,51	9,22
Targówek	1,58	0,656	2,78
Ursus	1,75	0,550	1,85
Ursynów	1,60	0,414	2,76
Wawer	3,86	0,774	3,50
Wesoła	1,21	0,685	3,37
Wilanów	1,31	0,540	2,29
Włochy	0,966	0,821	4,51
Wola	2,60	1,26	3,46
Żoliborz	3,03	1,42	4,45

The first difference between the absolute and relative scores is that the differences in values between the districts are much more narrow in the relative scores than they were in the absolute ones. The highest value for the relative transportation sum is five times larger than the smallest value, whereas, in the absolute terms, the highest value was 14 times larger. The highest value for the relative healthcare sum belongs to Ochota at 5,43 points, and the smallest to Bemowo gathering 0,432 points. The district with the highest absolute score for this dimension, Mokotów, amassed only 2,46 points, which is well below the largest values. For the education dimension, the results are very close, varying only from 0,388 (Białołęka) to 1,51 (Śródmieście). In the case of transportation, the district of Śródmieście maintained the highest value also in the relative terms at 9,22 points.

The dimension indices for the relative USAI are calculated in the same way as the dimension indices for the absolute index. As stated in section 1.5., the minimum values are 0. However, the maximum values for the healthcare, education and transportation dimensions are 5,43, 1,51 and 9,22 respectively. These data, as well as other values from table 5 and the formula from section 1.5. are used to create the relative dimension indices. The index values are present in the table below.

Table 6: Relative dimension indices for healthcare, education and transportation, for the districts of Warsaw.

District	Healthcare index	Education index	Transportation index
Bemowo	0,0795	0,269	0,219
Białołęka	0,0904	0,256	0,299
Bielany	0,287	0,536	0,366
Mokotów	0,453	0,643	0,386
Ochota	1,00	0,680	0,445
Praga Południe	0,423	0,552	0,358
Praga Północ	0,556	0,702	0,563
Rembertów	0,336	0,548	0,404
Śródmieście	0,769	1,00	1,00
Targówek	0,291	0,433	0,302
Ursus	0,323	0,363	0,201
Ursynów	0,295	0,273	0,299
Wawer	0,710	0,512	0,380
Wesoła	0,223	0,453	0,366
Wilanów	0,241	0,357	0,249
Włochy	0,178	0,542	0,490
Wola	0,479	0,830	0,375
Żoliborz	0,558	0,936	0,483

A noticeable difference in these indices when compared to the absolute dimension indices are the minimum values, especially for education and transportation dimensions. For these dimensions, the index values do not fall below 0,200, whereas in the absolute indices, the minimum values fell to about 0,070. Another difference is the much higher relative dimension indices for districts of Rembertów, Wesoła and Wilanów. These three districts noted the lowest absolute USAI values, however, for the relative dimension indices, the index values increased greatly. For example, Rembertów, which had healthcare absolute index value of 0,0821, has a value of 0,336 in the relative terms. This shows, that even if

the availability of public resources is low in the absolute terms, it is still sufficient for the number of people living in this district.

The data from table 6 and the formula from section 1.5. was used to calculate the values of the relative USAI. The values for this index are present in the table below and are sorted from the highest to the lowest value.

Table 7: Relative USAI values for districts of Warsaw.

District	Relative USAI
Śródmieście	0,916
Ochota	0,671
Żoliborz	0,632
Praga Północ	0,604
Wola	0,530
Wawer	0,517
Mokotów	0,483
Praga Południe	0,437
Rembertów	0,421
Bielany	0,384
Włochy	0,361
Targówek	0,336
Wesoła	0,333
Ursynów	0,289
Ursus	0,287
Wilanów	0,278
Białołęka	0,191
Bemowo	0,167

The highest relative USAI value belongs to Śródmieście. It is, therefore, a district with the highest availability of public services in both absolute and relative terms. Its score of 0,916 in the relative USAI is by far the best value, surpassing the second value of Ochota (0,671) by 0,245. Mokotów, being the district with the second highest absolute USAI value, fell in relative USAI rank with the score of 0,483. Such a value is mainly caused by a low value of the relative transportation index of 0,386, which greatly lowered the composite index. The districts of Białołęka and Bemowo noted the lowest relative USAI index values, which is caused mainly by the low values of the healthcare index.

A map was created in order to see how the relative USAI values for districts of Warsaw are situated geographically. The five different hues of red colour represent five different sets of values of the relative USAI.
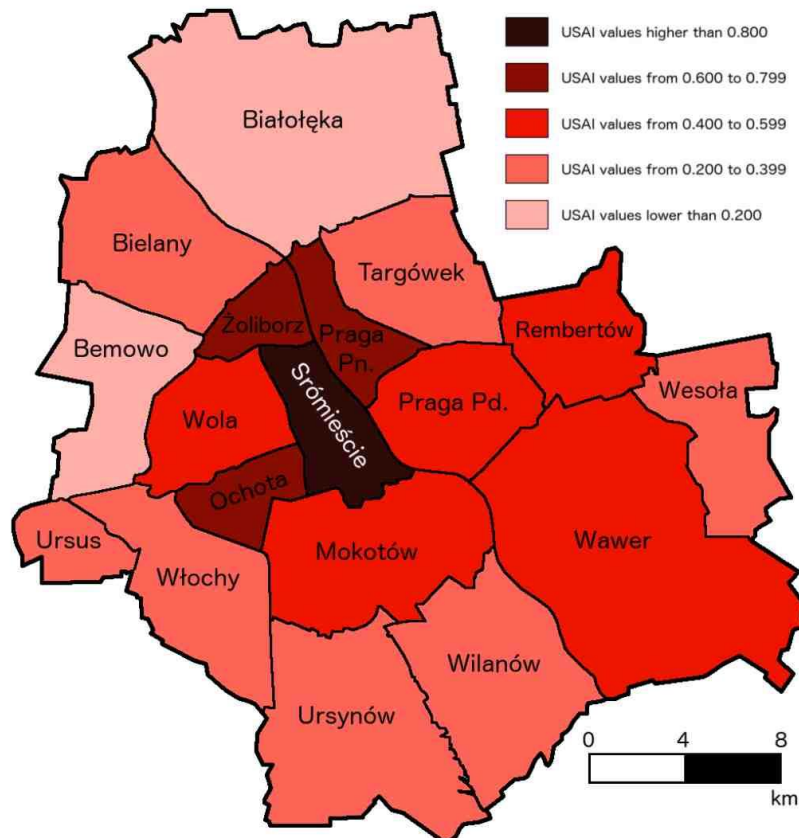

Figure 3: Pattern of the Relative USAI values in Warsaw

Districts with the highest value are situated near the centre of the city, similar as they were for the absolute USAI. What is different is that most of the peripheral districts, with exceptions of Bemowo and Białołęka, are not in the lowest range of values, i.e. lower than 0,200. Two of them, Wawer and Rembertów, with scores of 0,517 and 0,421 respectively, have managed to find themselves in the middle-value range.

2.1.3. Reference to the average apartment price

The relative USAI allows to equally compare the districts availability of public services as the absolute scores for each dimension are adjusted by dividing them by the number of people of a district. Therefore, the relative USAI shows the true availability and sufficiency of public resources of a district. To see whether the index can be regarded as reliable, it was referred to the average apartment prices of the Warsaw districts. If the prices were to correspond with the index values, the relative USAI could be regarded as a reliable index. The analysis of average apartment prices in Warsaw is based on the report published by website „domiporta.pl". It is one of the biggest real-estate sites in Poland, with over 800 thousand visitors per month. Only the prices of newly built apartments were considered. The rationale behind it is that in term of technical and architectural standards, newly built apartments are relatively homogenous in all districts, allowing for an equal comparison. The average prices for one square metre of an apartment in the districts of Warsaw are present in the table below (Redakcja Domiporta.pl., 2017):

Table 8: Average prices for one square metre of an apartment in the districts of Warsaw.

District	Apartment price for 1m² in PLN
Śródmieście	11918,97
Ochota	9123,02
Żoliborz	8707,35
Mokotów	8492,98
Ursynów	8041,97
Wola	7928,4
Bielany	7912,55
Wilanów	7735,17
Bemowo	7368,99
Praga Północ	7336,47
Praga Południe	7215,95
Włochy	7037,24
Targówek	6986,83
Ursus	6781,38
Wawer	6378,71
Wesoła	6294,53
Rembertów	5952,45
Białołęka	5827,71

Interestingly, the districts of Śródmieście, Ochota and Żoliborz have both the highest apartment prices and the relative USAI values. From the five districts with the lowest apartment prices, two of them also have the top five lowest relative USAI value. This show that relative USAI and average apartment price show similar trends. To see how strong is the correlation between the relative index and the apartment prices, a Pearson correlation test was conducted. The obtained value „r" was equal to 0,742, which is an account for strong positive correlation between the two sets of data. In this case, the test showed that there is a strong positive correlation between the values of the relative USAI and the average apartment prices in districts of Warsaw. The Pearson correlation coefficient for the absolute USAI was equal to 0,702. It is a borderline strong positive correlation; however, it is weaker than the correlation presented by the relative USAI.

3. Conclusion

The Urban Services Availability Index for the districts of Warsaw was calculated in two forms. Firstly it was expressed in absolute terms showing the overall availability of public resources in the districts. From the geographical presentation it was observed that the largest „absolute USAI" values are present in the central districts of Warsaw, and for the peripheral districts, the values are the lowest. The second form of the index, relative USAI, was the expression of availability of public services adjusted for the number of people living in a given district. Such a presentation allowed for an equal comparison between the districts and to see whether the capacity of public services in a district is sufficient for the number of inhabitants. The relative USAI values showed that once again, the highest availability of public services per one inhabitant is present in the central districts. However, the differences between the districts with high relative USAI values and the ones with low ones were much smaller in comparison to the differences present in the absolute USAI values. To see whether the relative USAI can be a reliable tool for comparison between the districts, it was referred to the average real-estate values of the Warsaw districts. A Pearson correlation test showed that there is a strong positive correlation, between the relative Urban Services Availability Index values and the average apartment prices, as well as higher correlation than the absolute USAI. The strong correlation proved that the relative index can be used as a tool to compare the

standard of living regarding the availability of public services, as well as be a determinant in choosing the most suitable district of Warsaw to live in. The design of the method of investigation was performed very well and allowed to develop trends in the collected data and to reach clear conclusions. However, the whole procedure of data gathering was time consuming, especially for the transportation dimension. If the study was to be repeated, a good improvement would be the simplification of the method for this dimension, which could lower the time consumption, yet still gather valid data. What could be even more interesting, is adding one or two more dimensions to the Index. An ecological dimension concerning the percentage of green areas in a district could be added, as well as a cultural dimension. Such additions would make the USAI an even more compound index, which could show stronger correlation with the market prices and be more useful in the comparison between the districts of Warsaw.

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