

IDENTIFICATION OF NEW URBAN CENTERS BY USING TAXONOMIC METHODS

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Abstract

Research background: In recent years, the return of city and suburbs dwellers to city centers has been observed. This phenomenon is caused in particular by the growing costs of transport and time spent on commuting. From this point of view, it seems interesting to observe the prices of properties located in the suburbs in relation to the prices of properties located around city centers and to examine their similarity. The center, however, should not be identified solely as the Old Town but rather as a certain area in which the professional, cultural and private life of the citizens is concentrated.

Purpose: The purpose of this paper is to find a method of identifying new city centers that allow developers to create a pricing map and, consequently, to determine the appropriate price level on the primary market. At the same time, it should help appraisers to capture the relationship between values of the properties located in different parts of a city.

Research methodology: The purpose of this study is achieved by deploying a taxonomic method (the modified density method) to identify new (or created) urban centers. The analysis is applied to the city of Wrocław.

Results: The findings reveal that it is clearly possible to identify visually clusters constituting new city centers by using the applied method. It is also possible to indicate in an analytical way the central location of a given center. The main advantage of the applied approach is that it is of universal use, suitable both for cities where one city center dominates, and for those where the dominant center is not present and is represented, for example, by the coastline of a sea.

Novelty: The density measure presented in the paper allows identifying city centers in an analytical way, based on given conditions. Habitants usually feel where the local center is, but it is not obvious how the prices of residential might spread out in space according to those centers. The measure can be easily modified by introducing new features that characterize the centers.

Keywords: city center, urban center, real estate market, similarity, valuation

JEL classification: A10, C10, C80, D46

Introduction

Observing the attitude of city dwellers in choosing the place of residence in the last decade leads to surprising and interesting conclusions. After years of settling in the suburbs, choosing larger properties (houses) at the expense of time spent on commuting, citizens are starting to return to city centers. Such conclusions come from the environment of people involved in analysing the real estate market as well as from practitioners like developers, property appraisers, and intermediaries.¹ From this point of view, a better understanding of the concept of the *city center* is required for a more accurate approximation of the analysed phenomenon. The city center does not have to be reflected by an Old Town Market Square,² neither does it have to be a geographically designated center of the area. What is more, according to the research carried out in this paper, several centers can be distinguished for a given city. Before we define the term, let us look at the general idea of the research.

According to the assumptions of this paper, the choice of a dwelling-place depends on the relationship between the distance from the city center and increase in the cost of access to the center, as well as the size of a flat (*ceteris paribus*). This problem can be considered in two ways.

The first one assumes that the potential buyer of the property has to spend a certain amount of money and within the selected budget he/she is trying to maximize the utility. Thus, a flat with a smaller surface, however located closer to the center, will be as useful as a flat with a larger surface, located at a distance of x km from the nearest center. Furthermore, the value of these apartments will be the same.³ It means that these properties may constitute a basis for similar properties from the point of view of valuation. Thus, when applying the paired comparison method, despite the differences in location the objects will be used for direct comparisons (Makowska, 2016)⁴ with obvious modifications resulting from the narrowly understood differences between these properties (for example standard or storey, but not the surface or number of rooms).

The second way assumes that the value of property according to the geographical location from the center decreases with the increase in this distance (*ceteris paribus*). Thus, by identifying

¹ It was emphasized during debates on Developer Days (12 October 2017, Wrocław) and the 14th Congress on Housing Real Estate Financing (30 November 2017, Warsaw).

² Numerous cities, such as Warsaw, do not have a separate market square, which results from historical conditions. There are also cities where centers form at many locations close to specific points such as Sopot or Gdańsk along the Baltic Sea coast.

³ It means the total value of the property. It is assumed that these values will be similar, because it is difficult to find exactly the same amounts.

⁴ Research based on the use of properties with different locations for a paired comparison approach was carried out in the doctoral thesis of the author of this article.

city centers in a given city, we can create a value map with isolines. These isolines combine points with the same values of a given location. This map may be further used for mass valuation by adjusting the unit base value of the property resulting from a given location and multiplied by the number of units (square meters), with additional features such as standard or floor location.

In both cases, the initial process of analysis is to find city centers. This paper presents the author's method of identifying them with the example of Wrocław. It constitutes an introduction to further research.

1. City center definition

According to the PWN Polish language dictionary (retrieved from <https://sjp.pwn.pl/sjp/centrum;2447510.html>), "*the center should be understood as the central part of something, the place where something is concentrated*" (reading from July 3, 2018). The city center is colloquially understood as the Old Town Square or, in the case of cities that do not have a market square, the area constituting the so-called "heart of the city", bringing people together by ensuring proximity to places of culture, commerce, gastronomy and entertainment. It is commonly assumed that a city has one center. It can be a compact area in a shape resembling a circle or an oval (for example Poznań, Kraków, Wrocław) or a very wide, extended area (for example the coastal line for coastal towns).

Some European cities are introducing or announcing restrictions on the accessibility to the city centers for diesel cars. They fight with exhaust fumes, limit transit traffic, and increase the relaxing and cultural role of this part of the metropolis.⁵ Another problem is the lack or low capacity of car parks, which makes traveling by car much more inefficient due to increased traffic, and consequently it results in a more difficult situation of enterprises located in close proximity to the city center. B. Podhalański (2008) claims, that "this causes the development of sub-centres which serve as an alternative to the real centre" (p. 74). This means that the city can be distinguished by more areas called the city center, which can have a variety of characteristics. For example, a center may be focused on financial, cultural and commercial activities. However, while in the case of such a large metropolis as New York, the financial center mainly gathers corporations, it seems that in European cities the functions of a given center are more mixed, and thus provide their residents access to most of them in one place.

⁵ Such a policy is used (or is intended to be used), among others in Oslo, Hamburg, Amsterdam, London, Paris, Prague, Brussels, Madrid, Helsinki, Copenhagen and Athens. Wrocław has been preparing for this for several years.

Taking into account the considerations mentioned above, this paper requires clarification of the concept of *the city center*. According to the assumption, this term should be understood as the public space, in which various functional specializations of a city concentrate, primarily residential, cultural, recreational (parks, green areas) and professional. However, the local center does not have to fulfil all of these functions, only selected ones. It is a place of meetings, trade, economic exchange and other activities, self-sufficient in terms of the expectations and needs of residents. Colloquially, it can be said that the center should have such functions that are able to meet the needs of residents so that they do not have to leave it too often. It means that the location is a true definition of city centre living, with everything nearby, including an array of theatres, shops, fitness gyms, cafes, bars and restaurants.

The multifunctionality of the center is an issue that is difficult to be implemented spatially, particularly in the field of green areas, which require significant space to feel the comfort of resting in silence and being close to nature. The efficiency of spatial development in cities requires reconciling various, often mutually contradictory, functions.

An interesting example of a city (metropolis) that distinguishes many local centers is Paris. It consists of 20 administrative districts (*arrondissements municipaux*), and each of them possesses its own center. Let us compare this example with another European metropolis – Athens. In this case, the oldest area of the city (the Acropolis) is not officially its center. This role belongs to the area that surrounds the Acropolis (Somoza, 2014, p. 15). It shows how widely you can treat the definition of the city center and how important it is to define its basic features, apart from the location itself.

2. Features characterizing city centers

At this stage, it should be considered which features of a given area affect the perception of it in terms of the center.⁶ Questionnaire surveys in this area were carried out in P. Lüscher and R. Weibel work (2010). It consisted of three parts. In the first one responders had to describe freely frequent activities, important facilities and physical appearance of a city centre. In the second part the participants were presented with lists of urban features and had to decide whether the features were typical of a city centre.

In the first part, the responders indicated the following activities as the most frequent ones: shopping (94.1%), eating out (44.6%), night-time entertainment (32.7%), working and doing

⁶ The center understood as the “heart of the city” and sub-centers or so-called local centers will be called from this place using one term, i.e. center, as the research carried out in the article does not differentiate these two models.

business (31.7%), going to theater and shows (31.7%), going to the cinema (21.8%), socializing in general (20.8%), using transportation (19.8%), sight-seeing and tourism (19.8%), visiting museums (18.8%), visiting art galleries and exhibitions (14.9%) and going to concerts (13.9%). In the second part of the survey among typical places that should be located in the center area were, among others, a commercial shopping center, theaters, night clubs, offices, restaurants, cinemas, museums, a library, a town hall, a railway station, main roads, and a park. Places not connected with the city center were: recreation complexes, factories, hospitals, stadiums or business offices and industrial centers.

One of the characteristic features of the centers that go beyond the research presented above is also the fact that it is usually a particularly well-kept area, which emphasizes its importance to citizens.

Taking into account the above-cited considerations, the following places and areas with specific functions whose occurrence can characterize the city center were adopted for the purpose of this work:

- office buildings,
- shopping malls, large-area shopping centers,
- commercial shopping centers,
- supermarkets, discount stores,
- places of culture,
- green and recreational areas,
- new housing investments,
- secondary housing market.

It is assumed that the center has to provide its residents, as well as to people living in its outskirts, with basic functions. One of them is an appropriate number of workplaces. In large cities, where a significant share of employees occupy the so-called market services, office space rented by large corporations and smaller companies may represent workplaces. Their large accumulation of them in one place may result in the center being identified with the financial district.

The commercial functions in large cities are fulfilled by large-scale commercial shopping centers, shopping malls, supermarkets and discount stores. Commercial shopping centers, apart from a large hypermarket, have other retail stores, as well as dining and entertainment venues. Shopping malls play a similar role, but their main profile is retail space with a smaller supermarket or delicatessen. It constitutes the majority of the commercial space of the building.

Cultural places include, in particular, cinemas, theaters, music venues and operas.

Green and recreational areas are parks, stadiums, recreation and sports facilities.

The center should also be a place of interest for developers. Thus, it attracts new housing investments.

The study also took into account the secondary housing market. However, it should be emphasized that this does not mean the number of flats in a given area, but the number of buy and sell transactions on the secondary market in the analysed period. It was assumed that the areas in which potential buyers are most interested can constitute the local center of the city.

3. Characteristics of the research

The research identifying new city centers was carried out in the city of Wrocław and concerned the year 2017.

Taking into consideration the above-mentioned features characterizing city centers, the following assumptions were made:

- a) according to data obtained from the Central Statistical Office, as of December 31, 2015 (Statistical Yearbook of the city of Wrocław, 2016), the largest share in the structure of employees in Wrocław was occupied by market services (49.7%), followed by industry and construction (19%). At the same time, the registered unemployment rate was around 4%. Hence, as places of work, the study took into account the location of office buildings of various standards and sizes (www.officemap.pl, retrieved from June 8, 2018);
- b) division into shopping malls and commercial shopping centers in the case of the city of Wrocław based on the indications of the official website of Wrocław (<https://www.wroclaw.pl/biznes/galerie-i-centra-handlowe>, retrieved from June 8, 2018);
- c) the location of cultural places, as well as green and recreational areas, was obtained on the basis of the Google Maps Tool, as well as on the expert knowledge of the author of this paper, resulting from the lore and from numerous analyses of the Wrocław real estate market;
- d) as a source of data on new housing investments, the “Catalog of Apartments and Houses” (2018) for Wrocław and the surrounding areas was used;
- e) data regarding the purchase and sale of residential real estate on the secondary market come from notarial acts signed in 2017 and obtained from The Board of Geodesy, Cartography and Cadastre of the City.

Using google.pl/maps cartographic service, all of the above-mentioned places and areas have been plotted on the map of Wrocław, as is shown in figures 1–7.

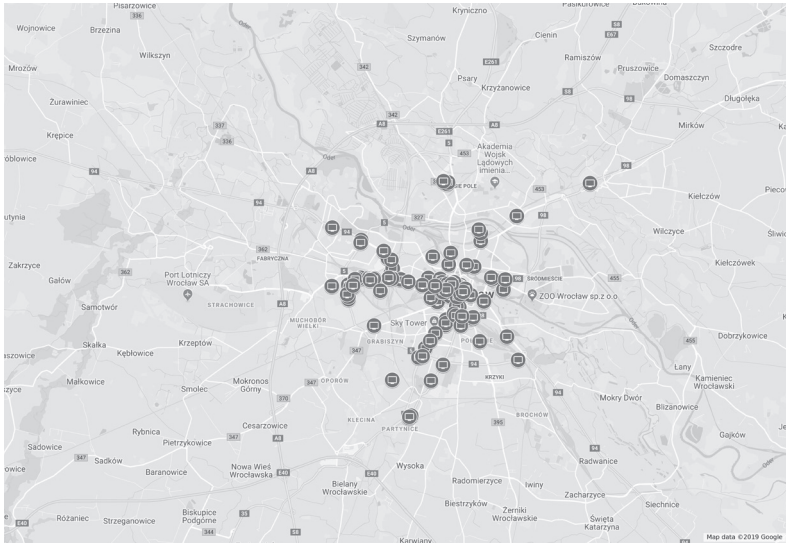


Figure 1. Location of office buildings in Wrocław

Source: own study based on officemap.pl and google.pl/maps.

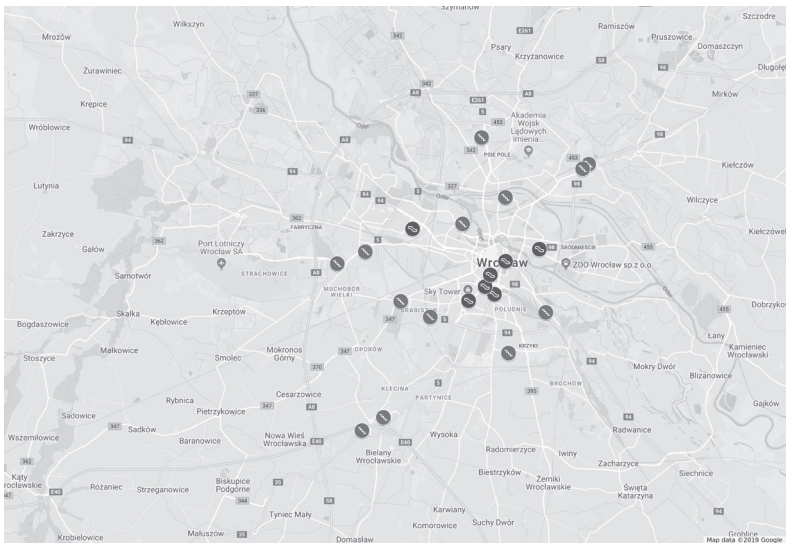


Figure 2. The location of commercial shopping centers and shopping malls in Wrocław

Source: own study based on google.pl/maps.



Figure 3. Location of supermarkets and discounters in Wrocław

Source: own study based on google.pl/maps.

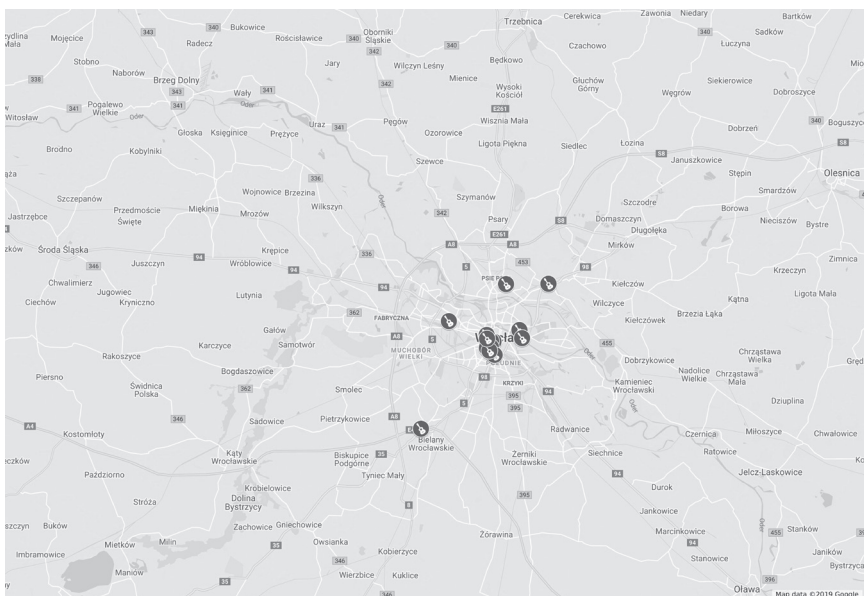


Figure 4. Location of cultural places in Wrocław

Source: own study based on google.pl/maps.



Figure 5. Location of green and recreational areas in Wrocław

Source: own study based on google.pl/maps.

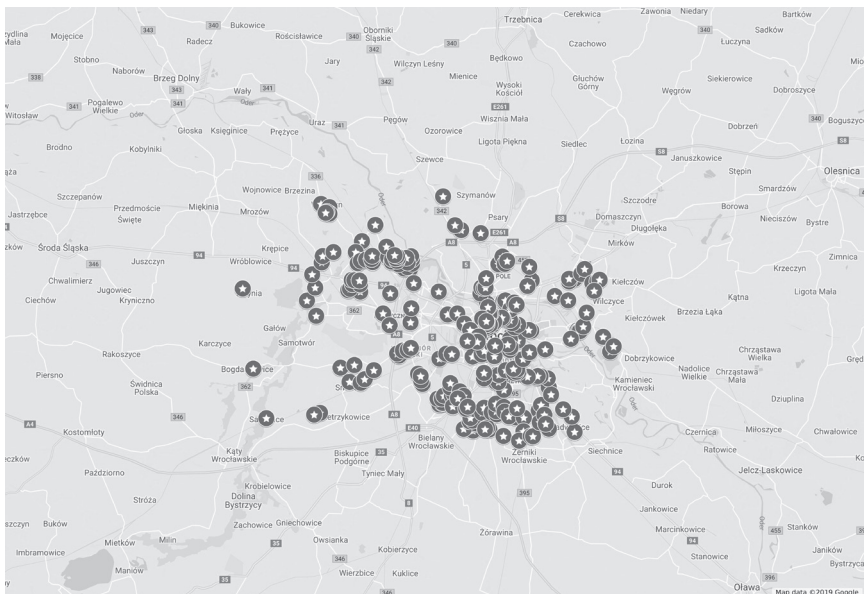


Figure 6. Location of new housing investments in Wrocław

Source: own study based on the Catalog of Apartments and Houses (2018) and google.pl/maps.

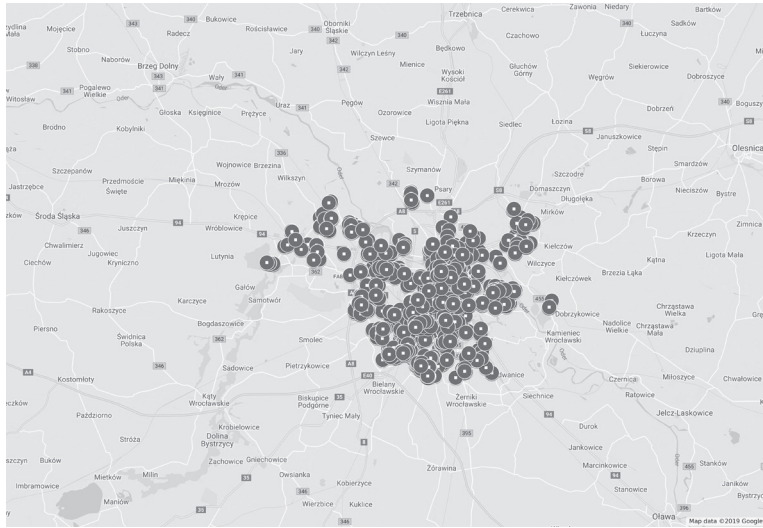


Figure 7. Purchase and sale transactions on the residential secondary market in 2017 in Wrocław

Source: own study based on notarial deeds obtained from The Board of Geodesy, Cartography and Cadastre of the City and google.pl/maps.

Taking the farthest points to the north, south, east and west as points of reference, a division was created on the map of Wrocław constituting a grid of 9.801 identical rectangular areas, 262×191 m in size (Figure 8).



Figure 8. A fragment of the division of the map of Wrocław into identical rectangular areas

Source: own study based on google.pl/maps.

Each of the vertices of the created rectangles can be an element of a potential cluster of a given local center; in particular, it can be the center of a given cluster.

Afterwards, the distance between each of the apexes of the rectangles and objects which were defined as characteristics of the city center was determined, using the formula 1 (Longley Goodchild, Maguire, Rhind, 2008). This distance represents the distance between two points on the surface of the earth.

$$L((\varphi_1, \lambda_1), (\varphi_2, \lambda_2)) = R_z \times \arccos[\sin\varphi_1 \sin\varphi_2 + \cos\varphi_1 \cos\varphi_2 \cos(\lambda_1 - \lambda_2)] \quad (1)$$

where:

L – arc length, distance between points,

R_z – the radius of the Earth,

φ_1, φ_2 – latitude, respectively of the first and second point,

λ_1, λ_2 – longitude, respectively of the first and second point.

4. Methodology

For the purpose of the identification of city centers in Wrocław, the author's modified density method based on M. Ester, H.P. Kriegel, J. Sander and X. Xiu work (1996) was used (see formula 2).

$$\bigwedge_{\substack{u(\varphi_1, \lambda_1) \in U \wedge \\ v(\varphi_2, \lambda_2) \in V}} L(u, v) \leq R_{n_u} \Rightarrow v \in Q_u \quad (2)$$

where:

$u(\varphi_1, \lambda_1)$ – a point with coordinates (φ_1, λ_1) belonging to the field of U ,

$v(\varphi_2, \lambda_2)$ – a point with coordinates (φ_2, λ_2) belonging to the field of V ,

$L(u, v)$ – distance between points u and v ,

R_{n_u} – the length n of the radius coming from point u ,

Q_u – cluster within the field of U .

The above-cited formula requires interpretation. The city center will be defined as the area that concentrates objects and areas mentioned previously among center characteristics. In other words, if the distance between the selected apex of the rectangle and the given object is smaller than the designated radius R_{n_u} , then this object will be a part of a given cluster. The more points in a given cluster, the greater the density of a given area. Thus it will be a potential city center.

A measure of density created for the purpose of this work is presented in formula 3.

$$g_{Q_u} = \begin{cases} X = 0 \wedge Y = 0 \Rightarrow 0 \\ X \neq 0 \wedge Y \neq 0 \Rightarrow \left(X + Y + \frac{d_{Q_u}}{D} + \frac{e_{Q_u}}{E} + \frac{h_{Q_u}}{H} \right) \times \frac{1}{7} \end{cases} \quad (3)$$

where:

- d_{Q_u} – number of new investments in cluster Q_u ,
- e_{Q_u} – number of supermarkets in cluster Q_u ,
- h_{Q_u} – number of apartment transactions on the secondary market in 2017 in cluster Q_u ,
- D – total number of new investments in the study,
- E – total number of supermarkets in the study,
- H – total number of apartment transactions on the secondary market in 2017 in the study,

and

$$X = \begin{cases} (\sim p \wedge (\sim q) \wedge (\sim r)) \vee (\sim p \wedge (r)) \vee (\sim p \wedge (\sim q)) \vee (\sim q \wedge (\sim r)) \Rightarrow 0 \\ (p \wedge q) \vee (p \wedge r) \vee (q \wedge r) \vee (p \wedge q \wedge r) \Rightarrow \frac{a_{Q_u}}{A} + \frac{c_{Q_u}}{C} + \frac{f_{Q_u}}{F} \end{cases} \quad (4)$$

where:

logical sentences:

- p – there is at least one office building in the Q_u cluster,
- q – there is at least one cultural place in the Q_u cluster,
- r – there is at least one green and recreational area in the Q_u cluster,
- a_{Q_u} – number of office buildings in cluster Q_u ,
- c_{Q_u} – number of cultural places in cluster Q_u ,
- f_{Q_u} – number of green and recreational areas in cluster Q_u ,
- A – total number of office buildings in the study,
- C – total number of cultural places in the study,
- F – total number of green and recreational areas in the study,

$$Y = \begin{cases} (s \vee t) \Rightarrow 0 \\ (s \vee t) \Rightarrow \frac{b_{1Q_u}}{B_1} \times w_1 + \frac{b_{2Q_u}}{B_2} \times w_2 \end{cases} \quad (5)$$

where:

logical sentences:

- s – there is at least one shopping mall in the Q_u cluster,
- t – there is at least one commercial shopping center in the Q_u cluster,

b_{1Q_u} – number of shopping malls in cluster Q_u ,

b_{2Q_u} – number of commercial shopping centers in cluster Q_u ,

w_1, w_2 – weights assigned to the participation of shopping malls and commercial shopping centers in the Q_u cluster (here: 0.7 and 0.3),

B_1 – total number of shopping malls in the study,

B_2 – total number of commercial shopping centers in the study.

According to the above-presented methodology, the following assumptions were made to calculate individual density measures:

- the analysed apex of a given rectangle will not constitute the city center if for a given distance R_{n_u} in the Q_u cluster will be at least two of the following objects: office building, cultural place, green or recreation area and at least one of the following trade centers: shopping mall, commercial shopping center,
- the density measure is greater when there is a shopping place in a given cluster and smaller when there is a commercial center in a given cluster, but it is required to identify the point as a center, so that at least one of these objects appears in the cluster,
- the density measure is the arithmetic mean of the density measures for individual objects and areas characterizing the city center.

In addition, for given distances R_{n_u} , where $R_{n_u} = \{0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5\}$, the weighted average was determined using proportional weights, linearly changing, where the highest weight was achieved for the smallest R_{n_u} . This gave a weighted average of the density measurements for respective apexes of rectangles (see Figure 9).

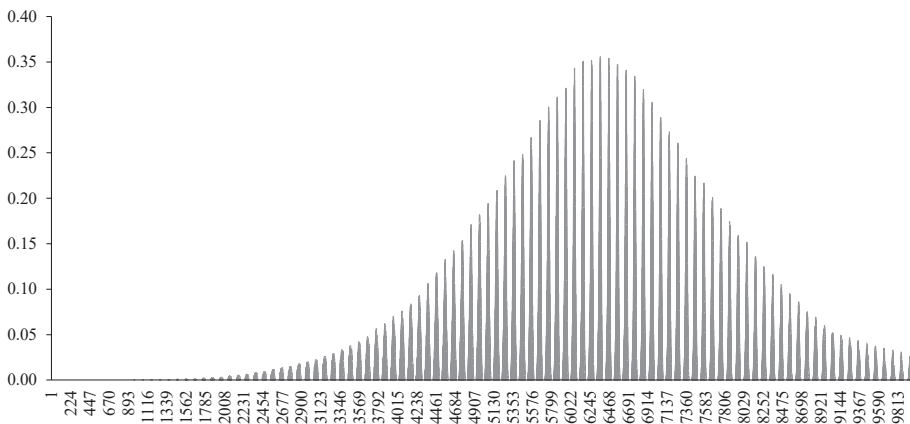


Figure 9. Weighted average of density measures for given radius R_{n_u} , for particular apexes of designated rectangles

Source: own study.

Figure 9 shows that while approaching the real city center (“the heart of the city”), the weighted average of the density measures increases, which may confirm the correct form of the measure.

Finally, on the map of Wrocław, weighted average density measures were presented, however only for points where the density measures were greater than 0, and the distance from the analyzed point was 2 km, 1.5 km, 1 km or 0.5 km. These visualisations are shown in figures 10–13, where the measurement values are arranged from the highest to the lowest, visualized by the gradient – from the darkest to the lightest shade.

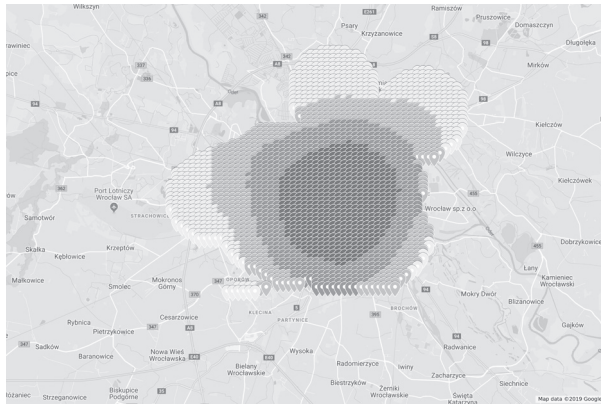


Figure 10. Weighted average density measures for a maximum distance of 2 km from the analysed point. From the highest to the lowest density – according to the gradient

Source: own study based on google.pl/maps.

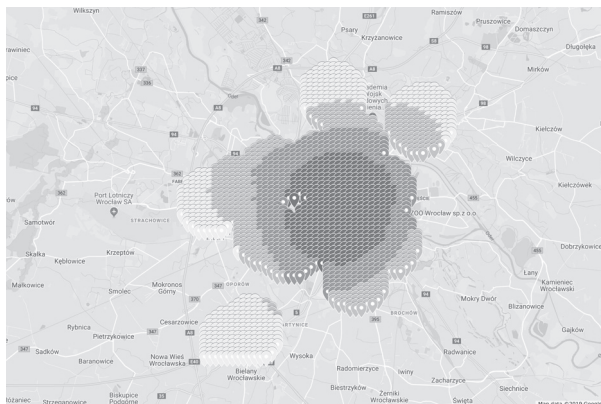


Figure 11. Weighted average density measures for a maximum distance of 1.5 km from the analysed point. From the highest to the lowest density – according to the gradient

Source: own study based on google.pl/maps.



Figure 12. Weighted average density measures for a maximum distance of 1 km from the analysed point. From the highest to the lowest density – according to the gradient

Source: own study based on google.pl/maps.



Figure 13. Weighted average density measures for a maximum distance of 0.5 km from the analysed point. From the highest to the lowest density – according to the gradient

Source: own study based on google.pl/maps.

The analysis of figures 10–13 may bring a conclusion that only at a distance of 0.5 km it is clearly possible to identify visually clusters constituting new city centers. However, providing

a high number of centers might cause the risk of losing the real city center. It is also possible to indicate in an analytical way the central location of a given center. That will be the point with the highest weighted average value of the density measure for a given cluster.

Conclusions

The density measure presented in the paper allows us to identify city centers in an analytical way, based on given conditions. The measure can be easily modified by introducing new features that characterize the centers. It is of universal use, suitable both for cities where one city center dominates, and for those where the dominant center is not present and is represented, for example, by the coastline of a sea.

However, after the study several questions and doubts occurred. The research was carried out with the example of a big city like Wrocław. Certainly, in the case of smaller cities the identification of local centers would be more difficult. In addition, a spherical distance measure was applied. However, the research should be repeated for an urban distance, which seems to be more appropriate for cities. Furthermore, the spherical distance for areas with a relatively small area taking into account the surface of the globe does not give significantly different results than the Euclidean distance.

Undoubtedly, one of the additional features that can be taken into account when identifying centers is the accessibility of public transport. The space development and the transportation network are usually closely related. In addition, the center is characterized by the proximity of various functions concentrated in one area to which access should be facilitated. If this condition is not met, citizens would not participate in the life of the local center (which in fact does not exist in this case), and things are done in various locations of a city.

According to the research idea described in the introduction, identified city centers can now serve for several purposes. The further stage of the research assumes completing a city map with prices derived from the purchase and sale transactions of residential real estate and examining the correlation between them and the distance from the nearest local center.

City centers may also help in choosing similar properties, whereas physically different objects mentioned earlier will be used for direct comparisons. They will constitute substitutes with reference to the increase in transport cost and time associated with commuting to the center as well as the increase in space.

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