

Geospatial Information to Support Real Estate Valuation

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SUMMARY

On the basis of the INSPIRE directive, the comprehensive supply of geodata has accelerated and improved considerably. Based on the improved data situation, the paper presents a model which combines numerous geodata which are relevant to describe the issue of "location quality". "Location" is one of the most important aspects according to record the situation of a landed property and to capture its value-relevant influence factors. The model is derived from free available and reliable geodata; the geodata are combined and weighted to about 15 influence factors per sub market (residential, office, retail and logistic). The influence factors are chosen as most relevant within a survey of property market experts.

The practical need for such a model is high, since the number and availability of direct real estate market data (sales cases) is often inadequate. The model developed is intended to support real estate valuation and market analysis by providing additional information, in particular for districts with few transactions. For example, the model is able to support the determination of Reference Land Values for each neighborhood, a yearly or biennial task of the Valuation Experts Committees in Germany. Thus, it contributes to the improvement of transparency in the real estate market, a priority objective for a well-functioning and reliable real estate market.

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1. MARKET TRANSPARENCY VERSUS DATA AVAILABILITY

The real estate market needs reliable information on the current conditions on the market (price level, supply and demand situation), differentiated by location and by type of property (**market transparency**). This is essential for a well-functioning market mechanism and for the estimation of appropriate real estate values, for example, to identify price bubbles and speculative effects. Market transparency is generated by reliable market information that is aggregated for an area (spatial sub-market), is up-to-date or related to a time spot (valuation date) and is available for everyone. Such information can be provided from both private market players and public institutions (Gudat & Voß 2012).

The creation of sufficient market transparency and the independent assessment of undeveloped and developed real estate has been the task of the official **Valuation Experts Committees in Germany** (Gutachterausschüsse) for more than 50 years. They are organized in the Federal States (Bundesländer), predominantly based on county level. The Committees have a splendid reservoir of market data, the official purchase price collection, which fully reflects the transactions on the market (obligation of the notaries to submit each purchase contract to the official purchase price collection according to § 195 BauGB).

A well-known product supporting market transparency in Germany are **Reference Land Values** published by the Valuation Experts Committees. They are updated yearly or biennial, today are called up more and more online and in some Federal States are part of open data initiatives and are available free of charge. It is stated that they have to be available for both undeveloped land, land in development and fully developed land - built-up as well as still unbuilt (§ 196 BauGB). The Reference Land Value mainly indicates the current average price per square meter of land (plot area) and refers to a neighborhood defined by the same structural features (Reference Land Value Zone). It represents the "location value" of this area and ideally should be derived from current purchase transactions.

Despite the supposedly good availability of market data from the official purchase price collection the number of reliable transaction data for valuations and market analyses is often not sufficient for analyzing different submarkets or using statistical methods. In many business parks, city center locations, multi-family housing estates or in rural villages, the transactions are hardly sufficient to map the market development in a reliable and differentiated way (called "**locations with few or no transactions**").

Here it could be helpful to consult other sources of information. Against this background, there is a research line coming up in the last years to include **additional information** into market analysis process and valuation procedures. The additional information can be gained by different sources, e. g. by expert opinions, by data from offering platforms, by cross-county comparisons etc (Dorndorf et al. 2017; Soot et. al. 2017; Soot et al. 2016; Alkhatib et

al. 2015). These data can support to capture the market situation although they do not represent market results directly.

This **paper deals with** another group of additional information – **geospatial data** or geodata. Geospatial data offer the advantage of spatial reference, which is essential for the real estate market, on the other hand geodata are not linked directly with a value-for-money reference.

The supply of free available geospatial information strongly increased in the last decade and will expand in the upcoming period of digitalization furthermore. Additionally, in Europe the nationwide supply of geospatial data has significantly accelerated and improved on the basis of the **INSPIRE** Directive (Directive 2007/2/EG of the European Parliament and the Council of Europe on „Infrastructure for Spatial Information in the European Community“ (INSPIRE). INSPIRE determines a list of 34 spatial information (geodata) which should be available and accessible on a nationwide level in each EU-country since this year 2019 (Themes ANNEX 1 – 3).

2. PROJECT APPROACH: LOCATION QUALITY FROM GEODATA

The **aim of the project** is the creation of an additional data basis from spatially relevant geodata. This model can be used additionally to support valuation of land and property. Due to their spatial reference, the geo-database contains rich information about a location or typical qualities of a location (location factors). The different "location qualities" derived from geodata should be suitable for depicting the value of a location relative to neighboring locations and comparable locations elsewhere. Particular attention is paid to the acquisition of information about commercial submarkets; next to the housing markets the office-, retail- and logistics submarkets will be examined. The basic research is funded by the "Lower Saxony Ministry of the Interior and Sports" and focuses on a model covering the area for the State of Lower Saxony (47.700 km², second biggest Federal State).

The "**location**" of a **property** cannot be captured by a single geodata, in fact it is a mixture of different geo-referred information. An aggregating model of a group of geodata is required which assesses the contribution of each geodata relevant to the quality of location as a whole. The intersection of a large number of geodata with socio-economic contexts forms the essential basis for the valence or significance of a location. In addition, we have to state that the property-relevant "location" is depending on the market; so a favorable residential area typically is not at the same time a good commercial location. The approach is based on the location analysis and thus captures the location factors (called indicators) as an important part of the price-forming factors of a property.

The model of determination of location quality by geodata for different real estate submarkets should meet several **requirements** (Bakker & Voß 2016, 24):

- The quality of the location should be mapped for the complete area of Lower Saxony and as detailed as possible (resolution should be as high as possible).
- The location quality should be determined in close link to the market, as objectively as possible and differentiated according to selected property submarkets.

- Furthermore, the option of periodic updating has a high priority when setting up the model. The model should work and be updated by automated individual calculation steps and GIS-based procedures.

The detailed scale of the required spatial information and its differentiation at a "neighborhood level" poses a special challenge. The model must finally prove that the particular value-relevant location indicators mixed and weighted from geodata are in relation to a high or low market value of a location. However, research and experience have shown also many not location-based influence factors which affect the market value of a property. For example, property values can be influenced by psychological or social circumstances which hardly can be grasped from geodata. Furthermore the results of the model are expected to give relative information from one location to another location at a state-wide level. An illustration of the price level in absolute terms (usually in €/m²) cannot be expected from the approach.

3. KEY ASPECTS OF THE MODEL DEVELOPMENT

The prehension of the “location” will require various indicators with different relevance for the respective real estate submarkets. For the modeling, on the one hand the regional or supra-local situation (macro-location) and on the other hand the small-scale differentiations up to the neighborhood level (micro-location) have to be depicted. This distinction is made on the basis of the location analysis (Ottmann & Lifka 2010). Macro and micro-location are described by different indicators and geodata. The model determines separate amounts for both levels, which are then contracted.

For modeling, various development steps have to be worked through, which have to be run through for the macro- and the micro-location:

- Selection of possible location indicators per sub-market (literature search).
- Allocation of freely available geodata to the selected location indicators (empiricism).
- Weighting of individual indicators by means of expert assessments as part of a priority analysis.
- Evaluation of the indicators for the respective location (degree of target achievement by means of GIS analyzes).
- Calculation of the location quality or the positional value from macro and micro-layer quality (utility value analysis).

Only a model that combines all the relevant information from geodata in an evaluative manner can provide information on the quality of a location in relation to the respective real estate submarket. The location quality is given in the model described here in a relative and unitless value. The model for calculating the positional qualities is created nationwide for Lower Saxony with a spatial resolution of 1x1 km. In densely populated areas, compaction takes place at 500x500 m cell size.

3.1 Macro and micro-location indicators

The "location" as one of the essential value-determining features of a location is widely discussed in the literature. On this basis, a comprehensive catalog with 80 stock-related indicators was compiled, from which expert surveys in the context of the priority analysis (see point 3.2) extracted the most important indicators for the macro as well as for the micro-stock. As a result, each of the 15 indicators has been designated by the experts as being of particular relevance (Fig. 1).

In a further step, suitable geodata will be assigned to the indicators in such a way that the collection of indicators from freely available and updated geodata can be ensured. To do this, it is sometimes necessary to combine several spatial data in order to map the desired indicator (see Fig. 1, eg population structure or proximity to nature). Corresponding intersections, especially for the distance-dependent micro-location indicators, are GIS-based (see basically Bill 2016).

	Location indiaktor	Record	
	Makro-location	unemployment	share of the unemployed development of the unemployed
employment		employment rate development of the employees	
household size		persons per household	
population growth		population growth (census)	
population structure		population density	
		part of the under-18s	
		share of 18-65 year olds	
		proportion of over 65-year-olds foreigners	
property tax levy rate		amount of the tax	
business tax rate		amount of the tax (netto)	
recreational value		share of recreational area	
		recreational area per inhabitant development of the recreational area	
type of municipality		shrinking or growing community	
		accessibility of regional centers	
		accessibility of middle centers	
job offer	Social insurance at work		
demand for jobs	number of unemployed / job offer		
economic power	gross domestic product		
	change in gross domestic product		
purchasing power	household income		
	development of household income		
tourist intensity	total amount per 1000 inhabitants		
	sleeping capacity utilization		
	durchschnittliche Aufenthaltsdauer		
proportion of graduates	employees at the place of residence with a university degree		
	employees at place of residence 30-35 years with university degree		
	employees at the place of residence with a vocational qualification		

	Location indiaktor	Record
	Makro-location	noise pollution
train noise aircraft noise		
close to public transport		
close to power lines		
close to education facilities		universities schools
close to health facilities		doctors
		hospitals
close to kindergartens		
parking possibilities		
shopping possibilities		
risk of technical catastrophes		
close to the city center		
immission impairment		
vacancy risk		
broadband quality		
close to nature	nature reserves	
	parks	
	forest waters	
contaminated sites exist		

Figure 1: Selected indicators of the macro- and micro-location with the respectively assigned geo datasets (own illustration).

3.2 Weighting of indicators through priority analysis

Undoubtedly, the above indicators are not all of the same importance for the quality of the situation. The indicators were weighted by expert interviews as part of a priority analysis. Weighting as objective as possible can be achieved through a broad sample of priority analyzes. For this purpose, 11 experts of the expert committee in Lower Saxony were interviewed in the first step. Currently, the results are verified by a nationwide survey of value appraisers.

The purpose of the priority analysis is to identify the most important and the next most important indicators. For this purpose, an indicator A is compared with each indicator B, C, etc., whereby each expert decides which of the two has the higher influence on the positional value of a particular type of property. With the help of a matrix, the so-called preference matrix, a large number of indicators can be systematically examined. The matrix serves as a structured comparison of all indicators (Fig. 2) and allows a subsequent weighting of the indicators among each other. The results of the priority analyzes of all experts are averaged to give the final weight of each indicator. Since the indicators for the different submarkets can be of different importance, a separate recording and analysis is carried out for each submarket. At the same time, this approach makes it possible to distinguish between the relevant and the less relevant indicators (see section 3.1 and Fig. 1).

indicator	A	B	C	...	total of the line	weighting	ω_i
A		0	0		0	0,0%	0
B	2		1		3	50,0%	0,5
C	2	1			3	50,0%	0,5
...							1

Figure 2: Example of the Priority Analysis (filling in the matrix with 2 = higher influence, 1 = identical influence or 0 = lower influence) (own illustration).

3.3 Assessment of indicators per location

An evaluation of the indicators is differentiated according to their spatial assignment to the micro or macro level. The indicators of the macro level are composed of statistical key figures, those of the micro level mainly of geometric features. The rating is based on a three-digit system with the numbers 1, 2 and 3. An evaluation with number 3 stands for the best possible rating of an indicator.

The valuation of the macro-location indicators is dependent on the total data volume of each indicator (reference level Lower Saxony). The average of an indicator is in the range of values

between the lower and upper quartile of its dataset. This area contains the middle 50% of the data. The values of an indicator outside of this data range are defined as above or below average. Thus, the location will be ranked according to the quartile of the indicator achieved (eg with a higher than average GDP rating 3).

For the evaluation of the micro-location indicators on the basis of distance measures, distance limits for the evaluation system were defined in a workshop with experts of the expert committee. Among other things, it was worked out at which distances a positive or a negative influence of an indicator on the value of a property arises and when this influence subsides or completely subsides. With the help of a geographic information system (GIS) the locations are selected depending on the defined boundaries and evaluated accordingly (eg within the distance with a positive influence with the rating 3).

3.4 Calculation of the total value of the location quality

From the totality of the indicators of the micro- and macro-location a location quality is calculated in each case. For this purpose, a value-analytical approach is used. This approach is a point evaluation procedure and is assigned to the qualitative analysis methods of decision theory (Fürst & Scholles 2008). Basically, in this process, different solution alternatives are to be evaluated with regard to an overall objective. This is done by determining a utility value for each alternative using a value function (Fig. 3). The utility value is a relative and unitless value that indicates "fitness for need determination". The real purpose of utility analysis is to systematically prepare a decision on a choice of alternatives (Zangenmeister 1971). The content and the purpose can be modified so that the actual value of the respective location quality of a community or a district, based on a specific type of property corresponds.

If the weighting of the location indicators was carried out with the help of the priority analysis (see section 3.2) and the evaluation (see section 3.3), the partial values can be calculated by multiplying them. The summation of the partial values, in turn, yields the total value (= utility value as a result of the utility value analysis), which represents the location quality in the real estate sub-market considered. The higher this value will be, the higher will be the quality of the respective location.

The final product of the model is a weighted combination of the calculated location quality of the macro and micro levels. The quality of the micro-location, due to the usual functioning of the real estate market is determined to be predominantly local and subject to the final validation results, the higher weight percentage is attributed.

alternative	proportion of unemployed people [%]			
	value r_1	valuation $\vartheta_1(r_1)$	weight ω_1	weighted $\omega_1 \vartheta_1(r_1)$
municipality 1	7,5	1	0,6	0,6
municipality 2	3,2	3	0,6	1,8
	recreational area per inhabitant [m ²]			
	value r_2	valuation $\vartheta_2(r_2)$	weight ω_2	weighted $\omega_2 \vartheta_2(r_2)$
municipality 1	68	2	0,4	0,8
municipality 2	148	3	0,4	1,2
	total value $\omega_1 \vartheta_1(r_1) + \omega_2 \vartheta_2(r_2)$			
Municipality 1	1,4			
Municipality 2	3			

Value function:

$$\vartheta(r) = \sum_{i=1}^m \omega_i \vartheta_i(r_i)$$

Condition of the value function:

$$\sum_{i=1}^m \omega_i = 1$$

Figure 3: Example for the calculation of the quality value with the value function of the payload analysis for the macro-location on the basis of two indicators (own representation).

4. PREVIOUS RESULTS AND VALIDATION

The research project shows that the presentation of a differentiated location quality for Lower Saxony is possible by a differentiated and value-added analytic aggregation of geodata inventories according to real estate sub-markets. To develop this model of a general location quality of an extended area (Federal State's area), based on available geodata, different model steps with different methods have to be implemented. The described model combines different spatial data for each grid cell to form a numerical value as the sum of the location indicators (dimensionless quantity). The calculation steps are implemented in a GIS in such a way that a periodic updating of the location quality from geodata is enabled in arbitrary and user-desired time periods. These numerical values indicate relative to each other a classification of the "location quality" in the sense of the real estate market relevant "location" (Figure 4).

As a further step, validation and optimization of the model based on market results is indispensable. Initial investigations have already made to test the plausibility of the results for the residential land sub market. This is done by a comparison with the existing Reference Land Values on the one hand and with the submitted property quotations in databanks on the other hand. It is necessary to transfer the land values and quotation data to the vector lattice structure; the mathematical adjustment enables a comparison with the results of the model of geodata-derived location qualities.

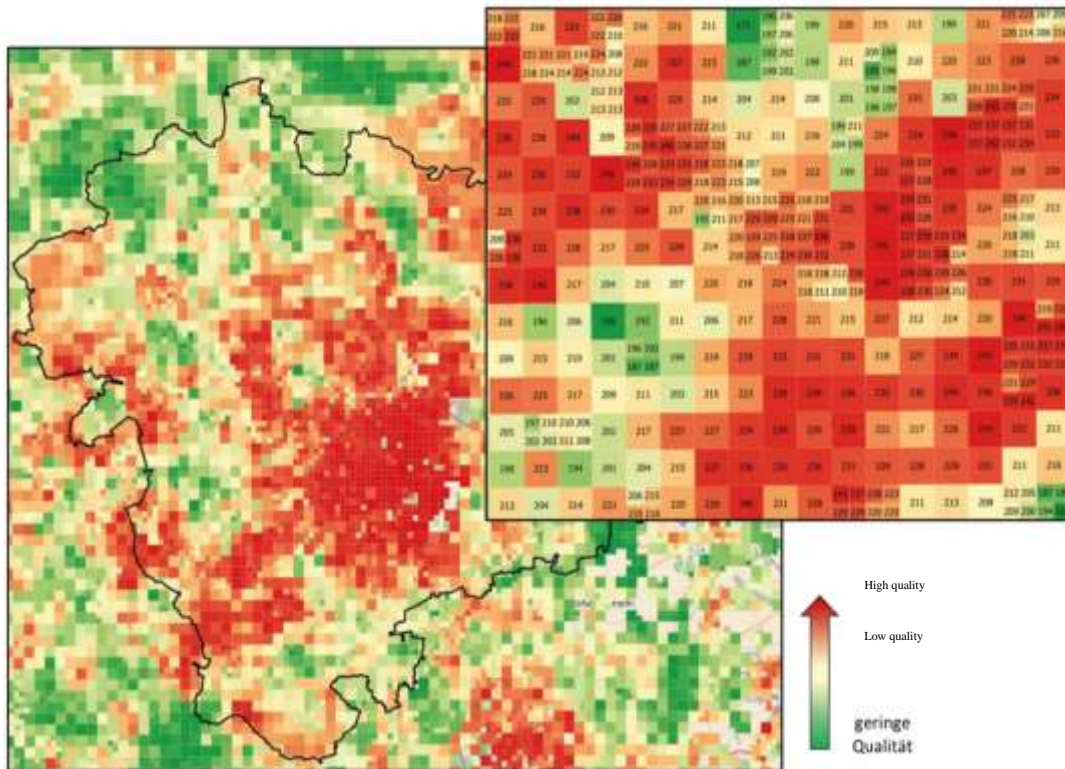


Figure 4: Location quality for residential real estate (Hannover region) shown and calculated on the basis of a grid of lattices (own illustration).

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BIOGRAPHICAL NOTES

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