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Influence of sustainable construction aspects and quality of public space on the price of houses in the Czech Republic

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Abstract. The construction industry produces 25 to 30 % of greenhouse gases and consumes 40 % of globally required energy. The construction industry and buildings contribute significantly to the climate change. Also the buildings are the cornerstone to the public space and affect its quality. One of the approaches to reduce greenhouse gas production (especially carbon dioxide) is the construction and operation of buildings according to the principles of sustainability. Houses are mostly not certified (environmental certification programs as LEED or BREEAM) because it is uneconomical to certify. However, the houses can fulfill sustainable construction aspects like using natural or recycled materials, design of energy efficient buildings, using alternative energy sources, connection to public transport, etc. The influence of using basic sustainable principles and quality of public space as an important part of sustainability to a price was tested through a database. The database consists of 98 samples of houses sold over the year 2017 in Brno - venkov district. Significant price settings factors were identified. Due to the number of variables, testing by multivariate regression analysis was performed on submodels, individual variables could be correctly identified. Tested database confirmed basic price setting factors for houses, such as the technical condition of the house, distance from the city of Brno, as well as the useable area of the house and the factor of liquidity. The influence of sustainable principles like using renewable energy, low energy demand, solar panels for hot water or photovoltaic panels was rejected. Some kind of sustainable principle was detected at 10 % of samples. Material base, especially using natural materials like timber, was not found as a price setting factor. One of the submodels was focused on the social part of the sustainability given to the location and public space. The possibility of using public transportation or car park close to the house was not confirmed as price setting factors affecting the price. Also the danger of flooding, index of criminality and noise level were considered and were rejected as price affecting. This paper presents results aimed at exploring the importance of the basic aspects of sustainable construction and quality of public space on the price of houses in the database of 98 houses in Brno - venkov district, Czech Republic.

1. Introduction

Sustainable development consists of three pillars: economic, environmental, and social, which need to be balanced. As a part of sustainable development, there is sustainable construction which significantly contributes to climate change. The construction industry is not only about the process of constructing buildings or infrastructure but also about building's lifecycle and building's operation. According to the principles of sustainability, it is necessary to reduce the production of greenhouse

gases through construction and building operations. The paper focuses on typical price setting factors that include sustainable constructions and technologies used at selling houses.

2. Literature review

There are many price setting factors which affect the price of real properties including houses. These factors are possible to divide into several groups, such as locality, public space and amenities, type, condition and equipment of the buildings. The following paragraphs are focused on price setting factors which are placed into the groups.

2.1 Locality

According to many articles, the locality is the most significant price setting factor. It usually includes good availability of amenities, such as school facilities, stores as well as working options and social life opportunities. It's confirmed by many studies. [1], [2]

2.2 Building

Many articles indicate technical conditions as a significant price setting factor. [3], [4] It goes hand in hand with the age of the building. Energy performance (class of energy labels) is derived from the age of the building and it affects operation cost as well. [5] Since climate change is a very discussed topic, there are researches focused on energy label and its effect on the price of buildings. [6], [7]

2.3 Sustainable features

One of the basic sustainable principles is using natural and renewable materials. Construction of timber based houses fulfills the idea of sustainability. Material base (like timber, concrete, bricks) of houses can affect the price as well as the construction cost. There are studies focused on the influence of material base on the construction cost [8], [9]. Only a few studies have considered the influence of material base on selling prices. [10] It shows that there is an influence of house material base on the selling price. It depends on the local house market and the popularity of each material base.

An inherent part of sustainability is also the use of renewable energy as well as reduced energy demand generally. According to the research from Japan [11], new green buildings (including green technologies as well) have a negative price difference. On the other hand, the price of the houses tends to increase after two years. Also, renewable energy such as photovoltaic and wind power generators is associated with greater costs of maintenance and replacement.

2.4 Transport, noise and criminality

For environmental protection, it is important to prioritize the use of public transport at the expense of private cars. Collins & Chambers inform in their articles that using private vehicles at the expense of public transport leads to climate deterioration. [12] Collins and Chambers note that "personal car use contributes to the environmental pollution, decreased air quality, greenhouse gas emissions, and fossil fuel consumption" [12]. Gerald T. Gardner & Paul C. Stern, "argues that domestic motor vehicle use, along with home space heating are the most important targets for emissions reduction." [13] Hunecke et al.note that the transportation sector accounts for around 10 % of greenhouse gasses globally. [14]

Noise in public space has a negative environmental effect according to Nijland et al. say that "today's urbanization will lead to noise being a bigger problem in the future unless efforts are made to mitigate the problem." [15] Day et al. points to road traffic noise which affects the price more than railway noise. [16] Same idea was also confirmed by Miedema and Oudshoorn. [17] Nellthorp et al.

draw attention to the fact that "the effect of traffic noise is often assumed to be negligible below an assumed baseline threshold at around 55 LAeq (measured outdoors)." [18]

Lorenc et al. informs that the urban environment may affect the health of inhabitants, especially the psyche caused by fear of crime. [19] This field is an important part of the social pillar of sustainability as well as the field of culture landmark and public space generally.

3. Methodology and data

The primary database of house selling prices in a selected locality was compiled. House market was monitored in a relatively compact area in the district of Brno - venkov in 2017. The district of Brno - venkov is an urban area (approximately 222 300 inhabitants) connected to Brno city (approximately 380 000 inhabitants). The district is bordered by a protected landscape area in the north and by an area of vineyards in the south. There is a great deal of agriculture and industry possibilities.

Real estate advertising was the cornerstone data source of the market. Individual offers from real estate advertisements have been continuously tracked and searching for the core information from the Land Register. For each house, there is an asking price and selling price available, as well as the time on the market. Selling prices have been requested from the Land Register.

Following characteristics have been registered for the houses (items of the database): the cadastral territory, address, asking price, selling price, time on the market, the year of selling, energy label, usable area of the house, size of the building plot and other information which was included in the real estate advertising. More information, which was needed to choose an individual variable, was traced in public resources.

Individual variables were chosen and divided into several groups as it is also mentioned in the literature review of this article, such as locality, public space and amenities or the type, condition and equipment of the buildings.

In the condition and equipment of the building group, the technical condition of the house, age, material base, the usable area of the house, size of the building plot, other appurtenances (for example shed, wine cellar, pergola et cetera), fireplace, above standard, shape of the roof and number of floors were included.

Variables connected to locality: public space and amenities or type: distance from the city of Brno, index of criminality and noise level, train to Brno, an important monument in the village, direct bus to Brno, parking, distance from Brno, population, criminality, catchment area.

For better recognition of price setting factors, indicators of the market efficiency were considered. The first one is the monitoring of asking price development until realizing a market transaction (ΔP). The second one is the time on the market for an individual offer.

The factor related to sustainable principles was considered. This factor included technologies, for example the use of renewable energy, solar panels for hot water or photovoltaic panels. All of them were tested as one variable called alternative technologies. Sustainable construction principles like material base or shape of the building were included as well.

The database consists of 98 items of houses sold over in the year 2017 in Brno - venkov district.

4. Results and discussion

Based on the multivariate regression analysis and the determined significance level of 0.05, the influence of the price setting factors was determined. Testing was performed on submodels that

individual variables could be correctly identified. Submodels and variables were divided into groups of the same structure as the literature review. The most affecting price setting factors are tested through all models to keep the high informative ability of models.

The first submodel (Table 1, 2) focused on basic price setting factors showed expected results that the most influential factors are the age and the condition of houses, distance from Brno (as a center of this region), size of the house and size of the building plot. Also, other appurtenances and a fireplace were found to be important price setting factors.

Table 1. First submodel: Statistical summary with the dependent variable (selling prices)

Statistical summary with the dependent variable: selling prices	
Statistics	Value
R	0.894497058
R2	0.800124986
Adjusted R2	0.771907337
F (12.85)	28.3554802
p	1.04814795E-24
Std. error of estimate	952283.66

Table 2. First submodel: Regression result with dependent variable (selling prices)

N=98	b*	Std. error b*	b	Std. error b	t (85)	p-value
Regression results with dependent variable: selling prices						
R= 0.89449706 R2= 0.80012499 Adjusted R2= 0.77190734						
F (12.85)=28,355 p<0,0000 Std. error of estimate: 9523E2						
Abs. mem.			-784529	873707.5	-0.89793	0.371759
usable area of the house	0.193253	0.055958	4534	1313.0	3.45354	0.000865
size of the building plot	0.139306	0.054614	392	153.5	2.55074	0.012541
distance from the city	-0.302086	0.054840	-70557	12808.8	-5.50850	0.00000
population	0.098566	0.056626	94	53.9	1.74066	0.085362
ΔP	0.124198	0.053749	1994107	862993.7	2.31069	0.023272
time on the market	0.037336	0.051499	1265	1744.5	0.72499	0.470452
age and the tech. condition	0.456876	0.062295	1091638	148845.5	7.33403	0.000000
train to Brno	0.002065	0.059022	9667	276264.9	0.03499	0.972168
other appurtenances	0.192271	0.052975	768611	211768.8	3.62948	0.000484
fireplace	0.206188	0.062914	965112	294483.8	3.27730	0.001519
above standard	0.050290	0.063181	294112	369501.1	0.79597	0.428266
alternative	-0.000916	0.052635	-6006	344940.8	-0.01741	0.986149

Another submodel (Table 3, 4) focused on sustainable features. All tested factors were rejected. There is no influence of tested price setting factors like the material base of houses (especially if wood was used), a number of floors and a roof shape as factors primarily influencing heat loss and energy demand. Also, the ability of sustainable principles like the use of renewable energy, low energy demand, solar panels for hot water or photovoltaic panels were not found to be price setting factors.

Any alternative technology was detected at 10 % of the items of the database. The market of houses fulfilling sustainable principles is not yet developed in the Czech Republic.

Table 3. Second submodel: Statistical summary with the dependent variable (selling prices)

Statistical summary with the dependent variable: selling prices	
Statistics	Value
R	0.874435251
R2	0.764637008
Adjusted R2	0.737583791
F (10.87)	28.26418
p	3.06783778E-23
Std. error of estimate	1021423.87

Table 4. Second submodel: Regression result with dependent variable (selling prices)

Regression results with dependent variable: selling prices

R= 0.87443525 R2= 0.76463701 Adjusted R2= 0.73758379

F (10.87)=28,264 p<0,0000 Std. error of estimate: 1021E3

N=98	b*	Std. error b*	b	Std. error b	t (85)	p-value
Abs. mem.			644092	595371.7	1.08183	0.282317
usable area of the house	0.177793	0.062360	4172	1463.2	2.85106	0.005441
distance from the city	-0.326857	0.055600	-76343	12986.4	-5.87868	0.000000
size of the building plot	0.134431	0.060906	378	171.2	2.20719	0.029933
age and the tech. condition	0.512452	0.066137	1224430	158024.4	7.74836	0.000000
other appurtenances	0.184447	0.055977	737335	223772.1	3.29503	0.001425
above standard	0.134474	0.064167	786444	375264.2	2.09571	0.039014
alternative	-0.018068	0.056610	-118407	370990.2	-0.31916	0.750367
material base	0.070121	0.057891	171569	141664.8	1.21126	0.229076
shape of the roof	-0.071376	0.058266	-590596	482117.0	-1.22501	0.223879
number of floors	0.113929	0.066344	458157	266797.7	1.71725	0.089492

Finally, the last model (Table 5, 6) focused on the field of public space and the option of transportation. All tested factors like criminality, bus and train connection to Brno, as an important catchment city and noise level, were shown to not affect the price of the houses at the database of 98 houses in Brno - venkov district. Only the options of a park close to the house or the use of their own garage were closely rejected at the significance level of 0.05.

Table 5. Third submodel: Statistical summary with the dependent variable (selling prices)

Statistical summary with the dependent variable: selling prices	
Statistics	Value
R	0.858906388
R2	0.737720184
Adjusted R2	0.700692445
F (10.87)	19.9234468
p	7.32391724E-20
Std. error of estimate	1090861.25

Table 6. Third submodel: Regression result with dependent variable (selling prices)

Regression results with dependent variable: selling prices

R= 0.85890639 R2= 0.73772018 Adjusted R2= 0.70069244

F (12.85=19.923 p<0,0000 Std. error of estimate: 1091E3

N=98	b*	Std. error b*	b	Std. error b	t (85)	p-value
Abs. mem.			451929	498617.2	0.90637	0.367305
usable area of the house	0.254909	0.064163	5981	1505.5	3.97283	0.000148
distance from the city	-0.275612	0.084902	-64374	19830.4	-3.24622	0.001674
size of the building plot	0.173018	0.063438	486	178.4	2.72734	0.007755
population	0.117448	0.079313	112	75.4	1.48081	0.142353
age and the tech. condition	0.537102	0.059980	1283328	143314.4	8.95463	0.000000
monument in the village	0.038974	0.073469	177359	334333.8	0.53048	0.597160
catchment area	-0.064575	0.085413	-67541	89334.7	-0,75604	0.451716
criminality	0.059381	0.064816	165659	180821.8	0.91615	0.362182
direct bus to Brno	0.090316	0.065814	360207	262486.1	1.37229	0.173584
noise	0.006872	0.058747	37862	323677.9	0.11697	0.907158
train to Brno	-0.029446	0.066671	-137830	312067.8	-0.44167	0.659852
parking	0.123017	0.065704	269050	143702.2	1.87227	0.064607

5. Conclusions

The construction industry and operation of buildings represent a large potential to reduce greenhouse gas production via buildings meeting sustainable principles. The research explores how the sustainability features affect the price and identifies the price setting factors of houses in Brno - venkov district of the Czech Republic. Pricing factors were tested on a database containing 98 items of houses.

According to multivariate regression analysis, the basic price setting factors were tested in three groups. The most significant factors were the age, condition of houses and distance from Brno. The size of the house and the building plot were shown as very important factors at the database of 98 houses in Brno - venkov district.

As stated by one of the submodels focused on sustainable features, there is no influence on the use of alternative technology such as heat pump, solar panels for hot water or photovoltaic panels on the price. The influence of the material base of houses and the building shape was not confirmed

as well. The market of houses fulfilling sustainable principles is not developed yet in the Czech Republic. Only 10% of the houses in the database have been detected to use alternative technology and less than 5% of items were built as timber houses.

Another tested submodel showed that all tested factors focused on the field of the social part of sustainability were not significant at the tested database. These were intangible pricing factors with regard to socio-economic factors and location factors, including crime as a sign of the public space, traffic noise, noise in the public space, transport in relation to the environment and the location of a significant monument in the immediate vicinity.

The next step of the research supported by a larger database should comprise statistical modeling divided into technical price setting factors as a material base or technical condition of houses etc. and social price setting factors as a neighborhood attributes or public space etc.

The research could be also generally useful as input values to the sales comparison approach in microeconomic contexts in Brno - venkov district of the Czech Republic.

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