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RELATIONSHIP BETWEEN ARCHITECTURAL STYLE AND PROPERTY VALUE IN THE CZECH REPUBLIC

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Abstract

This study investigates the influence of architectural styles on the value of housing units in heritage-listed apartment buildings across four Czech cities: Brno, Olomouc, Pilsen, and Ceske Budejovice (Budweis). Utilizing data from the National Heritage Institute, the Czech Statistical Office and Czech office for Surveying, Mapping and Cadastre, the research evaluates the relationship between architectural styles and property values using statistical methods, including Analysis of Variance (ANOVA). The findings indicate no statistically significant influence of architectural style on property values, contrary to international studies suggesting a price premium for historical styles. However, a statistically significant effect of location on property values was identified, particularly in Brno. The study highlights cultural and geographic differences in architectural valuation and suggests further research to refine valuation methods for heritage-protected buildings, considering additional factors such as building condition, proximity to amenities, and public infrastructure.

Keywords:

Architectural style;
Historic protection;
Locational influences;
Price influences;
Property values.

1 Introduction

1.1 Importance of historic centres in European cities

Historic centres have become the urban heart of European cities, giving the whole Europe a specific architectural charm. Historical architecture is a reflection of education and attracts tourists to European capital cities, thus also influencing the inflow of capital to these cities. That in turn affects the value of urban properties through the sharing economy [1]. It follows that historical buildings economically influence themselves and the buildings in their surroundings.

At the same time, it is important to mention the influence of architecture on the quality of life of the city's inhabitants and on their mental and physical health. The parts of the city where there are people on the streets throughout the day are naturally safer than the parts where there are no people at certain times of the day. When moving through the city, an individual has a greater sense of well-being and relaxation in busy streets. In order for people to actively participate in the use of public space, they need to be motivated, and this motivation can come from architecture as such. Gehl [2] came up with several ideas on how to support movement and life in urban spaces – one example is vertical separation of buildings, when a pedestrian passes by diverse architecture, which makes the path interesting. In contrast, the horizontal division of buildings, which can often be seen near the traffic arteries of cities, is downright discouraging from walking as the walk along such a street seems to be much longer and more boring. In this respect, the city parts with historical buildings are very picturesque. Another example is the commercial use of the ground floor (the first floor for speakers from some countries) and the construction of so-called soft border zones, in which life on the street interconnects with life inside the buildings and the boundaries between these two spaces partially overlap. In heritage-listed buildings, commercial public use of the ground floor, which also increases the attractiveness and thereby the safety of the urban environment, is not commonplace. The public commercial use of the ground floors of historical buildings comes with the necessity of more demanding legislation regarding the protection of heritage sites [2].

1.2 Application of Building Information Modeling (BIM) in heritage buildings

In recent years, efforts to implement Building Information Modeling (BIM) in construction practices have emerged [3, 4]. Currently, BIM is primarily applied to the planning of new buildings, but it is

expected to be increasingly used in the management of existing structures, including historical monuments. This approach could significantly aid in their valuation. However, historical buildings often contain numerous atypical elements from the perspective of modern construction practices, requiring the creation of unique databases for each structure [5]. In such cases, the information model is likely to include detailed data on the building's condition, incorporating results from non-destructive testing [6-10] and data on the layout of the building [11-14], including surrounding paved roads [9, 15].

It is also anticipated that some historical buildings will become the focus of the newly established Institute for the Valuation of Military Assets [16, 17], highlighting the growing need for specialized valuation approaches for culturally and historically significant structures.

1.3 Heritage protection and real estate market in the Czech Republic

Protection of heritage sites in the Czech Republic consists of two institutional sources. The first level of protection is managed by the National Heritage Institute, i.e. expert preservationists. Among other things, the National Heritage Institute issues written expert statements serving as sources for the executive bodies of the state administration, but it does not have decision-making power. However, there is a second level where state administration bodies (Ministry of Culture, regional authorities, municipal authorities and municipalities with extended powers) assess the written expert statements submitted by the National Heritage Institute and issue opinions and binding opinions on the matter under consideration.

In the Czech Republic, cultural monuments, national cultural monuments, protected areas and other sites of historical value are listed together in the Heritage Catalogue [18]. In this catalogue, in addition to the list itself, you can find basic descriptive data of each site, including photos and location on the cadastral map. The state currently protects approximately 40,000 immovable heritage sites, such as religious and sacral buildings, manors of aristocracy, diverse urban and rural buildings, technical monuments including transport structures, but also archaeological sites and cultural landscapes shaped by people. More than half of the heritage-listed buildings are used for residential purposes (according to National Heritage Institute) and appear on the real estate market. This article examines the relationship between the historical and economic value of these buildings. This is a relatively common case that experts on the economic value of properties encounter when issuing appraisals and estimates. This study uses the Heritage Catalogue mentioned above.

In the experience of the authors of this article, heritage protection in the Czech Republic is exercised through expert opinions in a way that at the time suits the expert: as an advantage or an aggravating circumstance for estimating the value of the given property. In their practice and at expert conferences, the authors of the article have come across opinions that individual architectural styles such as Art Nouveau, Neoclassicism or Functionalism increase the value of properties, while styles such as Brutalism or Modernism reduce the value of properties. That led them to the following questions: Does that mean that in terms of a property's value, some architectural styles are more advantageous than others? Does the architectural style actually affect the value of housing units (flats) located in heritage-listed buildings? And that is why this research aims to investigate and subsequently confirm or refute the influence of architectural style on the value of a property.

The authors of this study understand architectural style in the following way: Architectural style refers to a set of formal, aesthetic, structural and functional principles that characterize construction in a specific historical, geographical and cultural context. It is characterized by the morphology of the facades, the tectonic of the mass, the ornamentation, the construction solutions and the functional scheme, reflecting the technological innovations and socio-economic factors of a given era. The style-forming characteristics are shaped by urbanist relations, cultural heritage preservation and contemporary environmental trends. In the context of the real estate market, architectural style affects the value of real estate based on the degree of historical authenticity, prestige and maintenance costs, which determine its economic impact.

1.4 Influence of heritage protection on property value

Scientists and scientific groups have already asked similar scientific questions in the past. We divided these studies into two topical groups. Studies dealing with the influence of heritage protection on a property's value were included in one group, and studies dealing with the influence of architecture and its styles on a property's value were included in the other group. First, we will describe the studies on the influence of heritage protection on the property's value. Results of a study [19] showed that there are four groups of determinants of the value of heritage properties, namely transactional, structural, spatial and historical characteristics. For this article, the most important conclusion was that the value

of heritage properties differs by historical characteristics, especially by architectural styles or the design and condition of the heritage property itself. It was the aforementioned influence of architectural style on a property's value that this research focused on. In contrast, a group of researchers in Malaysia divided the assessed heritage properties into public and private and then determined a different valuation method for each group [20].

Although in Asian countries, the culture and the legislation historically linked to it is so different that the results of this research are not easily applicable in the countries of Central Europe, it is worth considering the initial division of heritage-listed buildings. Several case studies on the topic have been conducted in the Netherlands. One of them is a research into the effect of a building being listed as a heritage property on the price of the building itself and on the houses in its vicinity; in addition, this study monitors the effect on the prices of houses located in areas designated as a "cultural and historical site". The study found a price premium for all observed cases in the city of Zaanstad [21].

The results of another case study from the Netherlands go even further and quantify the value of the historical characteristics of buildings and their surroundings at almost 15% of the property's value [22]. In contrast, the scientific group around Warren [23] conducted their research from a completely different perspective and tried to assess and compare the impact of the location of vacant residential plots in historical districts on their value across Australia. The resulting finding is that these vacant lots for residential development sell at a premium of 10–11% compared to similar lots located outside historical districts. To the authors of this article, these studies have confirmed the hypothesis that historical architectural styles influence the value of properties in Czech towns and cities, however, none of the authors assumed that the price premium would reach similar values as in the aforementioned studies.

1.5 Influence of architecture and its styles on property value

The other topical area focused on the influence of the architecture itself and its individual styles on the value of a property or its immediate surroundings. Lithuanian research [24] looked into this topic. Its goal was to describe a theoretical framework that defines the structure and scope of architectural variables influencing the market value of properties. They concluded that there is a considerable number of architectural factors that could affect the value of a property; however, the situation is complicated by the fact that these factors are not clearly defined and the boundaries between them are blurred. Therefore, the researchers positioned these variables in the context of existing hedonic models.

Lindenthal and Jonson [25] conducted differently designed research. It examines economically significant price differences between buildings of different architectural styles, but not for the architectural style itself. Their results show that the Revival style has the most significant effect on price, as well as that modern neighbourhoods are clearly preferred over Georgian, early Victorian and post-war architecture. Nevertheless, as for this result, it could be debated whether modern neighbourhoods are preferred due to architectural rendering or due to functional factors that meet current housing requirements. From a research point of view, however, the architectural styles in England are diametrically different from those commonly found in Central Europe.

Similar results regarding the influence of architecture on the value of properties was done in the state of Massachusetts, U.S. provided by two groups [26, 27]. The first group of researchers [26] found out that buildings with older architectural styles in Newburyport sold at a premium ranging from 14 to 21%, and also found no evidence that location in a historical district increased a house's sales price compared to similar houses outside the district. In contrast research [27] conducted a case study in Boston where they looked at the impact of architecture on the value of terraced houses (row houses for speakers from some countries). The research results suggest that the older architectural style of individual buildings raised the value of terraced houses within the hedonic pricing model, while properties with a homogenous design were sold at a lower price. This shows that the diversity that has left its mark on individual buildings and neighbourhoods over the decades is often an advantage over modern homogeneity, when entire new neighbourhoods are planned and built in the same architectural style. Similarly, research in Rotterdam examined the influence of architectural shape homogeneity/heterogeneity between neighbouring houses on their value, but the results of this research are diametrically opposed.

Lindenthal [28] estimates a premium of 3.5% for terraced houses in very homogeneous units compared to buildings with heterogeneous neighbouring buildings. However, terraced brick houses are characteristic for Rotterdam, and there is only one similar town in the Czech Republic, Zlín, which has not been included in this research due to its significantly lower population. A differently designed study in Netherlands examined more than 60,000 property transactions in 86 housing estates in the country

and found a price premium of 15% for purely neo-traditional styles and 5% for referring to traditional styles.

The article goes on to describe the value of building styles in newly built houses. The research results show that as the production of neo-traditional dwellings increases, the price premium disappears. However, this does not mean that owners have stopped appreciating neo-traditional architecture, but rather that supply is catching up with demand [29].

Yet another perspective on research was chosen in Latvia where the role of architectural design on housing prices was evaluated. Pricing data are assigned to housing units of a limited number of architectural design prototypes [30]. The authors estimate implicit values of architectural quality in residential housing units as these are concentrated in a relatively small number of standardized designs. Their study is very transparent thanks to the large number of identically designed housing units within local housing estates. Similar housing estates, which would also have historical value, are not found in the research locations of this study.

Most of the research mentioned above confirms the positive effect of architectural influence on properties. The studies differ in their quantification of the price premium, which is obviously linked to the cultural location of each study. This article examines the area of Central Europe, specifically the Czech Republic. Any such research can contribute to the development of a functional valuation method for heritage sites and historical buildings in a given country. This study therefore aims to analyse, evaluate and demonstrate the possible influence of architectural style on the value of housing units in heritage-listed apartment buildings.

2 Methods

2.1 Specific conditions in the Czech Republic

The methodology of this research is shaped by the unique conditions of the Czech Republic. Owing to its historical context, the country is home to a diverse range of architectural styles, many of which have undergone modifications over time. Consequently, original-style buildings are relatively scarce. Additionally, a further limitation is that not all historical buildings are utilized or traded as residential properties.

2.2 Data sources

Key to assessing the research objective were price data from actual sales of housing units in heritage-listed buildings; the data were obtained from the database of the Czech Office for Surveying, Mapping and Cadastre. Another important source of data that was used in the study is the National Heritage Institute (NHI). The NHI administers the Heritage Catalogue [18], which serves as a record system containing information on cultural monuments, national cultural monuments, protected areas, protection zones and other sites that fall under the historic preservation.

The Heritage Catalogue includes the Central List of Cultural Monuments (CLCM), in which you can find basic descriptive data about each cultural monument, including its location (region, district, municipality, part of municipality, cadastral territory and address), photos and links to the location of the site in the cadastral map. Also available are CLCM catalogue numbers, information on heritage protection, stage of protection, general heritage protection, property type, category, architectural style, author identification and year of creation of the monument. Since these data sources are public and managed by government institutions, they are considered relevant and appropriate.

For the collection, analysis and synthesis of data from each research location, we used a uniform procedure. First, all price data on the realized sale prices of housing units (HU) from the years 2014-2022 were extracted from the database of the Czech Office for Surveying, Mapping and Cadastre [31]; they were then re-indexed, using the HB index, to the price level of 2022 and recalculated to the unit price per 1 m^2 of floor space of HU. In order to identify the housing units within the apartment buildings, the street numbers of the buildings in which the respective housing units were located were compared with the database of the National Heritage Institute [18]. This was the way housing units in heritage-listed buildings were analyzed.

Subsequently, additional information was acquired from the Heritage Catalogue [18], including data on heritage protection, the age of the property and the architectural style in which the individual buildings are built. This information was obtained for each housing unit from the previous analysis.

In the next step, a custom database was created for subsequent evaluation. This database contained key attributes such as housing unit number, address, street number of the building in which the housing unit was located, entry number of the price data, date of entry, price data itself, floor area of the housing unit, and information on historical preservation, age of the building and architectural style

in which individual buildings are built. This database provided the basic dataset for subsequent data synthesis and evaluation.

To evaluate the influence of the architectural style on the final sales prices, the whole compiled database was used, but certain modifications needed to be made. Grubbs' test was used to detect and exclude outliers. The test identified extreme (outlier) values, which could be caused by various factors, such as presence of luxury objects, problematic surroundings of an excluded locality, specific popularity of the object or extraordinary circumstances. These extreme values were subsequently excluded from the database. Duplicate records that could bias the results of the analysis were also removed, thus ensuring the reliability and integrity of the compiled database for further statistical evaluation. This measure ensured the purity and clarity of the dataset.

2.3 Research methods

To evaluate the statistical significance of the influence of architectural style on the value of the assessed properties in different locations, one-way Analysis of Variance (ANOVA) was employed; this method is used for data analysis in various areas of applied statistics. Using this method, the factors that influence the behaviour of a numerical quantity can be detected, their degree of influence can be assessed, and different groups can be compared in detail. Although almost 100 years have passed since Sir Ronald Fisher introduced this method in his paper "The Correlation Between Relatives on the Supposition of Mendelian Inheritance" [32], it still remains one of the most popular and frequently used statistical techniques.

The ANOVA (Analysis of Variance) method is often used to analyse differences between groups within an experiment. There are several different variations of the ANOVA method, including simple ANOVA, repeated measures ANOVA, and two-way ANOVA (ANOVA 2).

The ANOVA 2 statistical method was used to test all locations together. This statistical method is used to analyse two or more independent variables (factors) that may influence the dependent variable. This analysis makes it possible to determine whether there are significant differences between groups with respect to these factors. The two-way ANOVA, also referred to as ANOVA2, is suitable if we have two categories of factors that we want to investigate and find out their interaction.

The basic idea of the two-way ANOVA is that the dependent variable is affected by two factors and their interaction. This method tests set of three pairs of hypotheses of null hypotheses: H0x "There are no statistically significant differences between…" against alternative ones: H1x "There are no statistically significant differences between…" where x - means:

1: groups with respect to the first factor;
2: groups regarding the second factor;
3: the first and second factor.

The ANOVA 2 analysis provides output that includes F-statistics for both factors and their interaction, as well as p-values to determine whether the differences are statistically significant. If the ANOVA 2 results are statistically significant, we can perform post-hoc analyses such as Tukey's tests, Bonferroni corrections, etc. to determine which groups are statistically different from each other. Therefore, the two-way ANOVA is a useful tool for analysing data with two or more factors, allowing for a better understanding of their mutual effects on the dependent variable.

Additional statistical tests were performed to verify the prerequisites and use of the statistical methods described above. These tests are used to assess the normality of the data and the equality of variances. The following statistical tests were used:

The normality of the data was verified by a goodness-of-fit test using:

- Chi-Squared Test,
- Shapiro-Wilk test (Shapiro-Wilk W).

These tests were supplemented by a graphical evaluation of the skewness and kurtosis of the Gaussian curve. The test of standard deviations (equality of variances, so-called homoscedasticity) was verified using:

- Bartlett's test,
- Levene's test.

These tests are commonly used to assess prerequisites before using statistical methods. A goodness-of-fit test to verify the normality of data focuses on whether the data is normally distributed. The test for equality of variances determines whether the variances are equal between different groups of data. All results were evaluated in the professional statistical program Statgraphics Centurion.

3 Theoretical framework

3.1 Key terms

Some technical terms are understood differently in different scientific fields. In order to unify this conceptual diversity, key terms are presented as they were perceived in the context of the described research.

Cultural value: The cultural value of a building lies in its social significance, especially from the perspective of history, art or technology. It contributes to the understanding of the events, traditions, artistic development and technical skills of the area, as well as understanding of the overall cultural identity.

Architectural style: Architectural style usually refers to a period or historical time during which certain works of architecture were designed and built. The term includes common features, techniques, and elements that are characteristic of a given period. For example, Gothic style, Baroque style, or Modernist style are different architectural styles that differ in appearance and construction principles.

It can also refer to the specific design and aesthetic approach used in a particular work of architecture. These are specific expressive elements, ornamentation, and characteristic features that are used in architecture and that can be associated with a certain style.

Architectural style can be one of the factors that contribute to the cultural value of a building. Different architectural styles have their characteristic elements and they express, in an artistic and technical way, a specific period, location and sentiments in society.

3.2 Research location

3.2.1 City of Brno

The Statutory City of Brno is the second largest city in the Czech Republic in terms of area and population. According to data from the Czech Statistical Office [33] from 2022, 396,101 inhabitants live there. At the same time, the Brno Centre district is home to the country's third largest historic conservation area, which was created by a resolution of the Czechoslovak government in 1989. According to the records of the National Heritage Institute [18], there are currently 268 heritage-listed properties in this conservation area. The whole compiled database used to evaluate the influence of architectural style on the final sale prices contained a total of 166 records. The final database, after all modifications, contained 124 records.

In the compiled database of the cadastral territory of the city of Brno, a total of 5 architectural styles were detected in which buildings are built: Functionalism, Historicism, Neoclassicism, Modernism, and Art Nouveau.

3.2.2 City of Olomouc

The statutory city of Olomouc was one of the most important royal towns and it currently has 101,825 inhabitants [33]. The oldest part of the city is the historic conservation area, which is the second largest conservation area in the Czech Republic. The historic conservation area covers an area of approximately 87 ha with 697 house numbers. At the time of its creation, there were 264 objects in the conservation area, including town houses, churches, statues, fountains and city fortification, registered in the State List of Immovable Cultural Monuments. The whole compiled database used to evaluate the influence of architectural style on the final sales prices contained a total of 41 records. The final database, after all modifications, contained 34 records.

In the compiled database of the cadastral territory of the city of Olomouc, a total of 4 architectural styles were detected in which the buildings are built: Baroque, Functionalism, Gothic and Art Nouveau.

3.2.3 City of Pilsen

The statutory city of Pilsen is located in the Pilsen region in western Bohemia. It is the fourth largest city in the Czech Republic in terms of population and is located on the transport route that connects the capital city of Prague with the German city of Nuremberg. According to data from 2022, 181,240 inhabitants live there [33] and the area of the city is 138 km².

There are 155 buildings within the Pilsen historic conservation area that have been officially declared cultural monuments and have been assigned a register number in the Central List of Cultural Monuments. Most of these buildings serve residential purposes.

The whole compiled database used to evaluate the influence of architectural style on the final sale prices contained a total of 69 records. The final database, after all modifications, contained 39 records.

In the compiled database of the cadastral territory of the city of Pilsen, a total of 5 architectural styles were detected in which the buildings are built: Functionalism, Historicism, Neoclassicism, Cubism and Modernism.

3.2.4 City of Ceske Budejovice

The statutory city of Ceske Budejovice (Budweis) is located in the South Bohemian Region at the confluence of the Vltava and Malse rivers. 96,417 inhabitants live in this regional capital [33]. In 1980, the historic centre was officially declared a historic conservation area. In Ceske Budejovice, there is a culturally valuable historic centre, i.e. a historic conservation area with a large number of valuable ecclesiastical and secular buildings. The whole compiled database used to evaluate the influence of architectural style on the final sale prices contained a total of 36 records. The final database, after all modifications, contained 24 records.

In the compiled database of the cadastral territory of the city of Ceske Budejovice, a total of 3 architectural styles were detected in which the buildings are built: Baroque, Gothic and Renaissance.

4 Results

Before evaluating the databases of individual locations, it was first checked that the prerequisites are met for the use of the ANOVA statistical method. For each architectural style, an analysis of the normality of the price data was performed using a goodness-of-fit test, specifically the Chi-square test and the Shapiro-Wilk test. These tests were supplemented by evaluating the skewness and kurtosis of the Gaussian curve. Table 1 shows the results of the statistical tests for verifying the normality of the data in the individual research locations.

Table 1: Results of the tests verifying the normality of data from individual locations.

Normality test									
		Brno		Olomouc		Pilsen		Ceske Budejovice	
Arch. style	Test	Statistic	P-value	Statistic	P-value	Statistic	P-value	Statistic	P-value
Functionalism	Chi-Squared	10.6667	0.2213	14.7143	0.0117	13.4545	0.1994	-	-
	Shapiro-Wilk W	0.9214	0.2013	0.8165	0.0597	0.9578	0.4416	-	-
	Skewness Z-score	1.3636	0.1727	*		0.3014	0.7631	-	-
	Kurtosis Z-score	1.5664	0.1173	2.0268	0.0427	-1.0270	0.3044	-	-
Art-Nouveau	Chi-Squared	8.1579	0.5183	9.5714	0.2964	-	-	-	-
	Shapiro-Wilk W	0.9849	0.9733	0.9623	0.7189	-	-	-	-
	Skewness Z-score	0.0099	0.9921	0.7116	0.4767	-	-	-	-
	Kurtosis Z-score	0.7428	0.4576	0.2593	0.7954	-	-	-	-
Modernism	Chi-Squared	9.3333	0.5008	-	-	4.8000	0.3084	-	-
	Shapiro-Wilk W	0.9651	0.6115	-	-	0.9204	0.5347	-	-
	Skewness Z-score	0.4954	0.6203	-	-	*		-	-
	Kurtosis Z-score	-0.3088	0.7575	-	-	-0.9576	0.3383	-	-
Historicism	Chi-Squared	10.1475	0.8973	-	-	4.6667	0.4579	-	-
	Shapiro-Wilk W	0.9608	0.1106	-	-	0.8679	0.2125	-	-
	Skewness Z-score	1.1868	0.2353	-	-	*		-	-
	Kurtosis Z-score	-0.4017	0.6879	-	-	-1.6363	0.1018	-	-
Neoclassicism	Chi-Squared	5.5000	0.4815	-	-	5.3333	0.0695	-	-
	Shapiro-Wilk W	0.9544	0.7561	-	-	0.9025	0.3934	-	-
	Skewness Z-score	0.2762	0.7824	-	-	*		-	-
	Kurtosis Z-score	-0.1198	0.9047	-	-	5.0037	0.0000	-	-
Baroque	Chi-Squared	-	-	4.6667	0.4579	-	-	9.6667	0.2083
	Shapiro-Wilk W	-	-	0.9019	0.3723	-	-	0.9010	0.1561
	Skewness Z-score	-	-	*		-	-	0.9566	0.3388
	Kurtosis Z-score	-	-	-1.0125	0.3113	-	-	*	
Gothic	Chi-Squared	-	-	3.2857	0.6560	-	-	4.8000	0.3084
	Shapiro-Wilk W	-	-	0.9578	0.8107	-	-	0.9018	0.4166
	Skewness Z-score	-	-	*		-	-	*	
	Kurtosis Z-score	-	-	-0.3536	0.7236	-	-	*	
Renaissance	Chi-Squared	-	-	-	-	-	-	5.5714	0.3502
	Shapiro-Wilk W	-	-	-	-	-	-	0.8862	0.2653
	Skewness Z-score	-	-	-	-	-	-	*	
	Kurtosis Z-score	-	-	-	-	-	-	*	
Cubism	Chi-Squared	-	-	-	-	10.4000	0.0342	-	-
	Shapiro-Wilk W	-	-	-	-	0.7962	0.0752	-	-
	Skewness Z-score	-	-	-	-	*		-	-
	Kurtosis Z-score	-	-	-	-	1.7429	0.0814	-	-
Note: * Insufficient data									

Another prerequisite for the use of the ANOVA statistical method was the verification of the equality of variances, the so-called Homoscedasticity. Homoscedasticity of the examined data was verified using the Bartlett and Levene tests. Table 2 shows the results of the statistical tests for verifying the homoscedasticity of the data in the individual research locations.

Table 2: Results of the homoscedasticity tests of data from individual locations.

Variance Check								
	Brno		Olomouc		Pilsen		Ceske Budejovice	
Test	Statistic	P-Value	Statistic	P-Value	Statistic	P-Value	Statistic	P-Value
Levene's	-	-	0.4105	0.7466	-	-	-	-
Bartlett's	1.1538	0.0023	-	-	1.1002	0.5718	1.0946	0.4141

After verifying the prerequisites for the use of the ANOVA method, a separate statistical evaluation was carried out for each research location. It included the application of ANOVA and other post-hoc tests to examine the relationships and differences in influence of various architectural styles on the price data of housing units.

4.1 City of Brno

1. Normality: The results of the statistical tests to verify the normality of the data for the city of Brno are shown in Table 1. Since the lowest p-value among the performed tests is greater than or equal to 0.05, we cannot reject the hypothesis that all architectural styles come from a normal distribution with 95% confidence. The results were also confirmed by the statistical indicators Skewness and Kurtosis Z-score, which are not greater than 1.96 (corresponding to the 5% level of significance), so there is no statistically significant difference in the skewness and kurtosis of the data set compared to the normal distribution.

2. Homoscedasticity: The statistical tests shown in Tab. 2 tested the null hypothesis claiming that the standard deviations of the Prices in each of the 5 levels of Architectural Style are equal. Since the condition of data normality was met, Bartlett's test was used. Since the p-value of the tests for Brno is less than 0.05, there is a statistically significant difference between the standard deviations at the 95% confidence level. This violates one of the important prerequisites for analysis of variance (ANOVA) and invalidates most standard statistical tests. For this reason, the Kruskal-Wallis test (K-W test) was chosen for the ANOVA evaluation.

3. ANOVA: The K-W test was used to test the null hypothesis that the median prices in each of the five levels of architectural style are equal. Data from all levels were first combined and sorted from smallest to largest and the average rank was calculated for each level. Given the p-value greater than 0.05, no statistically significant difference was found between the medians at the 95.0% confidence level.

In the city of Brno, no statistically significant effect of architectural style on the value of residential units in heritage-listed apartment buildings was proved with 95% confidence.

Table 3: Kruskal-Wallis data test for the city of Brno.

K-W Test for Price by Architectural Style		
Architectural Style	Sample Size	Average Rank
Functionalism	15	46.6667
Historicism	61	67.6393
Neoclassicism	8	66.0000
Modernism	21	54.8571
Art-Nouveau	19	65.4737
Test statistic = 5.31429 P-Value = 0.256542		

4.2 City of Olomouc

1. Normality: The results of the statistical tests to verify the normality of the data for the city of Ceske Budejovice are shown in Table 1. Since for most architectural styles, the lowest p-value among the performed tests is greater than or equal to 0.05, we cannot reject the hypothesis that all these architectural styles come from a normal distribution with 95% confidence. However, this was not confirmed by the tests for the architectural style of Functionalism. For this style, the data cannot be considered a random sample from a normal distribution. For this reason, in the evaluation of the ANOVA results, its non-parametric form was used.

2. Homoscedasticity: Subsequently, Homoscedasticity was tested. The results of the statistical tests are shown in Table 2. Since the condition of normality was not met, Levene's test was used to test

the equality of variances. As the p-value of Levene's test is greater than 0.05, we do not reject the null hypothesis, which means the condition of homoscedasticity was met.

3. ANOVA: During testing, it was found that not in all architectural styles, the data can be treated as a random sample from a normal distribution. For this reason, a non-parametric analogue of ANOVA, the so-called K-W test, was used again.

The K-W test tests the null hypothesis that the median Prices within each of the 4 levels of Architectural Style are the same. Data from all levels are first combined and sorted from smallest to largest. An average rank is then calculated for the data at each level. Since the p-value is greater than or equal to 0.05, there is no statistically significant difference between the medians at the 95.0% confidence level.

In the city of Olomouc, no statistically significant effect of architectural style on the value of residential units in heritage-listed apartment buildings was proved with 95% confidence.

Table 4: Kruskal-Wallis data test for the city of Olomouc.

K-W Test for Price by Architectural Style		
Architectural Style	**Sample Size**	**Average Rank**
Baroque	6	18.6667
Functionalism	7	20.4286
Gothic	7	13.8571
Art-Nouveau	14	17.3571
Test statistic = 1.62737 P-Value = 0.653197		

4.3 City of Pilsen

1. Normality: The results of the statistical tests to verify the normality of the data for the city of Pilsen are shown in Table 1. Since the lowest p-value among the performed tests is greater than or equal to 0.05, we cannot reject the hypothesis that all architectural styles come from a normal distribution with 95% confidence. The results were also confirmed by Z-test and its statistical indicators Skewness and Kurtosis Z-score, which are not greater than 1.96 (corresponding to the 5% level of significance), so there is no statistically significant difference in the skewness and kurtosis of the data set compared to the normal distribution. The standardized skewness test looks for a lack of symmetry in the data; however, as the results show, for some architectural styles, it was not possible to calculate a standardized skewness.

2. Homoscedasticity: Since the condition of data normality was met, Bartlett's test was used for homoscedasticity. The results of the statistical tests are shown in Table 2. Since the p-value is greater than 0.05, there is no statistically significant difference between the standard deviations at the 95.0% confidence level.

3. ANOVA: Since all conditions for the use of ANOVA were met (data normality, homoscedasticity), the F-test and Mood's median test were used for evaluation. The ANOVA table factors the price variance into two components: a between-groups component and a within-groups component. The F ratio, equal to 0.752077 in this case, is the ratio of the between-groups estimate to the within-groups estimate.

Since the p-value of the F-test is greater than or equal to 0.05, there is no statistically significant difference between the average price from one level of Styles compared to other styles at the 95.0% confidence level.

Table 5: F-test of data for the city of Pilsen.

ANOVA Table for Price by Architectural Style					
Source	**Sum of Squares**	**Df**	**Mean Square**	**F-Ratio**	**P-Value**
Between groups	5.42E+08	4	1.36E+08	0.75	0.5636
Within groups	6.13E+09	34	1.80E+08		
Total (Corr.)	6.67E+09	38			

Mood's median test tests the hypothesis that the medians of all 5 samples are equal. It counts the number of observations in each sample on either side of the grand median, which is equal to 54,696.0. Since the p-value for the chi-squared test is greater than or equal to 0.05, the sample medians are not significantly different at the 95.0% confidence level.

Also included (where available) are 95.0% confidence intervals for each median based on each sample's rank statistic. In the city of Pilsen, no statistically significant effect of architectural style on the value of residential units in heritage-listed apartment buildings was proved with 95% confidence.

Table 6: Mood's median test for the city of Pilsen.

Mood's Median Test for Price by Architectural Style						
Total n = 39. Grand median = 54,696.0						
Architectural Style	**Sample Size**	**n<=**	**n>**	**Median**	**95.0% lower CL**	**95.0% upper CL**
Functionalism	22	11	11	54,795	47,705.6	65,057.7
Historicism	4	1	3	66,581		
Neoclassicism	3	2	1	48,538		
Cubism	5	4	1	46,449		
Modernism	5	2	3	62,444		
Test statistic = 3.30987 P-Value = 0.50737						

4.4 City of Ceske Budejovice

1. Normality: The results of the statistical tests to verify the normality of the data for the city of Ceske Budejovice are shown in Table 1. Since the lowest p-value among the performed tests is greater than or equal to 0.05, we cannot reject the hypothesis that all architectural styles come from a normal distribution with 95% confidence.

2. Homoscedasticity: Since the condition of data normality was not violated, Bartlett's test was used for homoscedasticity. The results of the statistical tests are shown in Table 2. Since the p-value is greater than 0.05, there is no statistically significant difference between the standard deviations at the 95.0% confidence level.

3. ANOVA: Since all conditions for the use of ANOVA were met (data normality, homoscedasticity), the F-test and Mood's median test were used for evaluation. The ANOVA table factors the price variance into two components: a between-groups component and a within-groups component. The F ratio, equal to 2.18 in this case, is the ratio of the between-groups estimate to the within-groups estimate. Since the p-value of the F-test is greater than or equal to 0.05, there is no statistically significant difference between the average price from one level of Styles compared to other styles at the 95.0% confidence level.

Table 7: F-test of data for the city of Ceske Budejovice.

ANOVA Table for Price by Architectural Style					
Source	**Sum of Squares**	**Df**	**Mean Square**	**F-Ratio**	**P-Value**
Between groups	1.33E+09	2	6.65E+08	2.18	0.138
Within groups	6.41E+09	21	3.05E+08		
Total (Corr.)	7.74E+09	23			

Table 8: Mood's median test for the city of Ceske Budejovice.

Mood's Median Test for Price by Architectural Style						
Total n = 24, Grand median = 53,369.5						
Architectural Style	Sample Size	n<=	n>	Median	95.0% lower CL	95.0% upper CL
Baroque	12	7	5	52,042	42,465.2	62,577.2
Gothic	5	1	4	76,710		
Renaissance	7	4	3	52,034		
Test statistic = 2.27619 P-Value = 0.320429						

Mood's median test tests the hypothesis that the medians of all 3 samples are equal. It counts the number of observations in each sample on either side of the grand median, which is equal to 53,369.5. Since the p-value for the chi-squared test is greater than or equal to 0.05, the sample medians are not significantly different at the 95.0% confidence level. Also included (where available) are 95.0% confidence intervals for each median based on each sample's rank statistic.

In the city of Ceske Budejovice, no statistically significant influence of architectural style on the value of residential units in heritage-listed apartment buildings was proved with 95% confidence.

5 Results – ANOVA 2

After performing a unifactor analysis of variance (ANOVA), which did not show a statistically significant influence of architectural style on real estate prices in individual cities, a subsequent bifactor analysis of variance (ANOVA 2) was performed. The aim of this analysis was to examine the influence of all locations simultaneously, which was carried out by merging data sets from individual cities, thus creating a much larger data corpus with the potential to prove the aforementioned influence.

The main purpose of this analysis was to test the aggregate effect of the locations, since by integrating data sources from individual cities, a much larger dataset was created that might be able to identify the researched effect. Simultaneously, a hypothesis of a bifactor analysis was examined regarding the degree of influence of individual locations (cities) on the prices of the investigated housing units, with regard to the city size and number of inhabitants, which was carried out in order to analyse diverse factors influencing real estate prices. The compiled dataset included 225 observations of price data, which represented the dependent variable, with locations and architectural styles as the independent variables.

First, it was checked that the prerequisites for the use of the statistical method ANOVA 2 were met by testing the normality of the data, which was performed using a modified Kolmogorov-Smirnov test. The modified Kolmogorov-Smirnov test is a statistical method used to test the fit between an empirical data distribution and a theoretical distribution. This test is a useful tool for analysing data and determining whether the data is distributed according to a certain theoretical distribution, which is important in statistical analysis and modelling.

Table 9 presents the result of the test, the purpose of which was to assess whether the Price can be adequately modelled by a normal distribution.

Table 9: Modified Kolmogorov-Smirnov D.

	Normal
D	0.064222
Modified Form	0.971508
P-Value	>=0.10

Since the smallest of the p-values, within the tests performed, is greater than or equal to the 0.05 level, we do not have sufficient evidence to reject the hypothesis that the Price exhibits normality at the 95% confidence level. The Kolmogorov–Smirnov test checked and demonstrated the normality of the data. Subsequently, the compiled dataset was analysed using a two-factor analysis of variance (ANOVA 2).

The ANOVA table factors the variability of the Price into contributions resulting from various factors. Since Type III sums of squares (default) were chosen, the contribution of each factor is measured after removing the effects of all other factors.

P-values test the statistical significance of each of the factors. Since the p-value of the independent variable A: Location is less than 0.05, this factor has a statistically significant effect on Price at the 95.0% confidence level. However, the p-value of the researched independent variable B: Architectural style is not statistically significant, so the influence of architectural style on the prices of assessed properties was not proven again, even after merging all the described databases. No interaction was proved between the assessed factors of location and architectural style, therefore ANOVA 2 without interaction was used for the evaluation.

Table 10: Analysis of Variance for Price – Type III Sums of Squares.

Source	**Sum of Squares**	**Df**	**Mean Square**	**F-Ratio**	**P-Value**
A: Location	2.5443E10	3	8.48101E9	36.85	0.0000
B: Architectural Style	1.67414E9	9	1.86015E8	0.81	0.6092
RESIDUAL	4.87952E10	212	2.30166E8		
TOTAL (CORRECTED)	9.86457E10	224			

Note: All F-ratios are based on the residual mean square error.

Table 11: Multiple Range Tests for Price by Location Method: 95% LSD.

Location	***Count***	***LS Mean***	***LS Sigma***	***Homogeneous Groups***	
Olomouc	36	56,467.2	3,092.88	X	
C. Budejovice	24	57,885.0	4,477.90	X	
Pilsen	39	57,982.6	3,432.86	X	
Brno	126	84,782.0	2,850.68		X

This table uses the multiple comparison method to identify statistically significant differences between group means. Specifically, Fisher's least significant difference (LSD) method is used in this analysis. The results show that the locations of Olomouc, Ceske Budejovice and Pilsen are statistically equivalent, as indicated by the "X" symbols, which are aligned in a vertical line in the right column, while the city of Brno shows a statistically significant difference compared to the other locations, thus the "X" symbol is significantly deviated from this vertical line. Further, contrast estimates were performed.

Contrast estimates in ANOVA 2 are statistical methods used to identify and quantify differences between different combinations of factors within a two-factor analysis. These estimates help determine whether there are significant differences between groups in a two-factor analysis and how large those differences are.

Table 12: Contrast.

Contrast	*Significance*	*Difference*	*+/- Limits*
Brno – Olomouc	Significant difference	28,314.8	6,874.96
Brno – Pilsen		26,799.4	6,478.31
Brno – C. Budejovice		26,897.0	10,359.2
Olomouc – Pilsen		-1,515.42	8,399.29
Olomouc – C. Budejovice		-1,417.81	9,391.13
Pilsen – C. Budejovice		97.6132	11,312.7

The table shows the differences between the means in different pairs. An asterisk symbol for three pairs indicates statistically significant differences at the 95.0% confidence level. It follows that the city of Brno shows statistically significant differences compared to other localities, while no statistically significant differences were found between the pairs of locations Olomouc – Pilsen, Olomouc – Ceske Budejovice and Pilsen - Ceske Budejovice. The described finding is clearly illustrated by the following graphic representation, using LSD intervals (estimates of mean values).

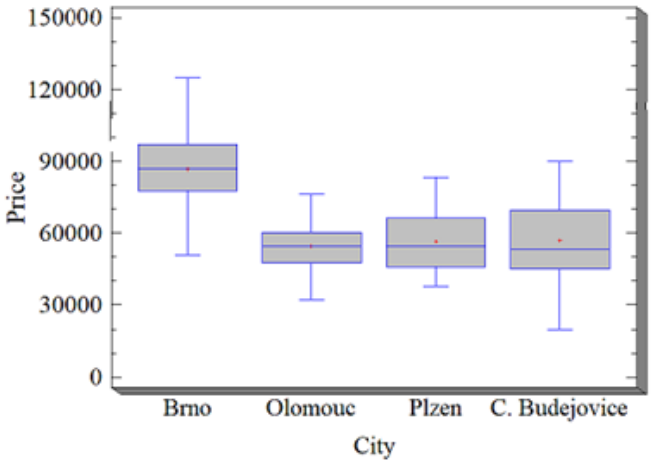

Fig.1: Means and 95.0 percent LSD Intervals.

Although the average prices in the locations of Olomouc, C. Budejovice and Pilsen differ, the differences are not statistically significant. From the visual representation of the data in the box graph, it can be clearly found that the only statistically significant difference in average prices, as compared to other localities, is in the city of Brno.

6 Discussion and Conclusion

The objective of this study's conclusion is to summarise the key results of the research, aim of which was to analyse the influence of architectural style on the value of housing units in heritage-listed apartment buildings in selected Czech cities. The study conducted in historic centres of the cities of Brno, Olomouc, Pilsen and Ceske Budejovice used data from the National Heritage Institute and the Czech Office for Surveying, Mapping and Cadastre. The analysis employed two statistical methods - namely Mood's median test and the K-W test, which are tools based on analysis of variance (ANOVA).

In the next step, all the available databases from the researched cities were tested and analysed together without interaction, with the use of the statistical method ANOVA 2. The results of these tests did not prove a statistically significant influence of architectural style on the value of properties in the analysed locations. That means the hypothesis of the influence of architectural style on the property value was not confirmed.

These results contrast with findings from several international studies that suggest a price premium associated with historical architectural styles. This discrepancy may be attributed to cultural and economic factors specific to the Czech Republic. In some countries, such as the Netherlands or the United States, historic architecture is often perceived as a luxury feature that enhances property value. In contrast, Czech buyers may prioritise practical considerations such as the building's condition,

maintenance costs, and accessibility to services. Furthermore, the regulatory complexity and financial burden associated with restoring heritage-protected buildings may negatively impact their market attractiveness. Another important factor is the dominant influence of location on property value, which was confirmed by the analysis, particularly in Brno. The higher property prices in Brno compared to Olomouc, Pilsen, and Ceske Budejovice suggest that economic opportunities, infrastructure, and service availability play a more significant role in determining property value than architectural style.

One of the main objectives of this study was to contribute to the development of a new valuation method for heritage-protected buildings in the Czech Republic. At the moment, the study has not proved itself to be an efficient tool for progressing the field of heritage-protected building valuation. On the contrary – at its end, it presents suggestions for further research in the field, which may bring a deeper understanding of the influence of architectural style on property value. To achieve a more accurate and general valuation of results, conducting a more extensive and long-term study with a higher amount of price data is recommended. The expanded research might cover various geographical areas and more factors possibly influencing the value of housing units in heritage-protected buildings. Such factors can include, for example, the condition and age of a building, the proximity of public transport, and public amenities and services in the neighbourhood. The results of this particular study are valid only for the specific sites and models used in the analysis.

A separate topic for further research is the influence of the prices of reconstruction work on historical buildings [34] on the value of real estate.

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