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AKADÉMIAI KIADÓ

Surveying methods and instruments for heritage properties, using decision tree and Artificial Neural network analysis

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RESEARCH ARTICLE

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ABSTRACT

This paper demonstrates the application of surveying methodologies aiding the management of heritage properties, especially for UNESCO World Heritage sites. The objective of the current study is to provide an overview of the historical background of surveying a particular field of engineering and the related social environment. In Europe, all types of historic streets and avenues share a centuries-long common history. Investments financed by governments, capital or residential sources relating to these streets have provided opportunities for interesting architectural experiments. This study demonstrates the intensity of these investments and the morphological and functional changes in relation to their distance from the CBD. To achieve this objective, based on an on-line database of housing features and values, apartments (n = 1,031) from the range of Residential Real Estates in Teréz Town Budapest were collected. Data statistics tools included a Decision Tree and an Artificial Multi-layer Neural Network employed in order to analyse inequalities in price according to the condition of the property and available conveniences. The characteristics of monocentricity/polycentricity are shown to be adaptable elements that have been used historically in urban landscapes and can be implemented in urban design to enhance green spaces and improve the overall quality of urban life. As good examples, the Andrássy/Hübner - Court and the ICOMOS prize-winning renovation of the Wahrmann Palace are presented. Real estate can carry both real and philosophical meaning. Sometimes buildings express physical reality in the environment, at others, they have a symbolic meaning, e. g. an urban idyll, harmony with the habitat, local community, heritage property, wealth or poverty, integration or segregation of people or families. Functional changes support long-term decision-making for investors and city residents in search for better locations within global cityscapes.

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KEYWORDS

surveying, property management, statistics, goodwill value

1. INTRODUCTION

Throughout history, human beings have used different ancient disciplines including architecture, geodesy, law, philosophy, and mathematics to manage real estate - res immobiles. Besides ancient disciplines, there exist younger disciplines including urban studies, sociology, facility management, life-cycle assessment, economics, environmental psychology, and information technology to support scientific analysis and research into real estate management. This paper is an attempt to analyse both the real and the philosophical meanings of real estate and to merge the traditional and the younger disciplines (Wagner, 2012). Many scientists believe that it is very important to apply the sciences in an interdisciplinary manner, demonstrating their interconnections. There are different branches of science, but only one science of nature. It is necessary to protect nature in more efficient ways than our current practices. It would also be necessary to respect and adopt the scientific results of other nations, cultures, and civilizations (Lewis, 1966; Róka-Madarász and Mályusz, 2013). Ancient Egypt was one of the greatest and earliest civilizations. The earliest records of land ownership date back to the Royal Registry of Ancient Egypt that was created in about 3000 BC. The world's oldest surviving papyrus map, the Turin map, was drawn about 1160 BC for King Ramesses's IV of the New Kingdom's 20th Dynasty Period. A recent reassessment of Stonehenge (c. 2500 BC) suggests that the monument was set out by prehistoric surveyors using peg-and-rope geometry. The Bible further indicates that surveyors were active in Jerusalem, defining property boundaries and ownership. The Greek astronomer, mathematician, and geographer Eratosthenes of Cyrene (276–195 BC) calculated the Earth's circumference using triangulation based on the hypotheses of Pythagoras and Aristotle. In his three-volume work, *Geography*, he created the first map of the world incorporating parallels and meridians. The Romans are said to have used the plane table in laying out their impressive road system. The first such road, with its perfectly straight sections, was the Via Appia named after Appius Claudius Caecus, also known as "regina viarum". A plane table consists of a drawing board mounted on a tripod or other stable support. It has a straight edge – usually with sights for accurate aiming of the alidade to the objects to be mapped – along which lines are drawn. It was the first device capable of recording or establishing angles. The levelling instrument used by the Romans was the simple libella.

In 1086 William the Conqueror wrote the Domesday Book which covered all of England and contained the names of the land-owners, the amount of land they owned, the quality of said land, and specific information about the resources and people four in each area. In the 16th century after Galileo's discovery of the telescope, Johannes Kepler also embarked on a theoretical and experimental investigation of telescopic optics. The Keplerian telescope has two convex lenses that can produce higher magnification than Galileo's combination of convex and concave lenses. The study of astronomy resulted in the development of angle-reading devices that were based on arcs of large radii. In the 17th century, in 1620, the English mathematician Edmund Gunter developed a surveying chain that was superseded only by the steel tape which appeared in the late 19th century. Later on, Sir Isaac Newton and Christian Huygens searched for

a mathematical theory for determining the shape of the Earth. Newton believed that rotation would bring about a flattening, with the polar radius smaller than the Equatorial radius. Indeed, the Earth is approximately spherical, but there is a slight flattening towards the poles – a consequence of rotation in the period of the planet's formation during the early history of the solar system. When Munich was occupied in 1800, the commanding general of Napoleon's French Army, Decaen, ordered the making of an astronomically and geographically accurate map of Bavaria. After the French had retreated, Max I. Joseph, later to become King of Bavaria, founded the Topographic Office in 1801. He wanted to make a topographic atlas of Bavaria on a scale of 1:50,000 that would be useable both for military and civilian purposes. In 1808 Napoleon Bonaparte founded the cadastre (from the Greek κατάστιχον = account book) – a comprehensive register of the properties of a country, which recorded ownership details, location, and information about the value and usage of the land. It also included maps drawn to scale, both at a ratio of 1:2,500. Sir George Everest was made Surveyor General for the Great Trigonometrical Survey in 1830, hence the English name was given to Chomolungma. Important technological developments followed in the 20th century. The military requirements of the two World Wars were to bring about photogrammetry, or mapping via aerial photographs. Revolutionary changes were the use of satellites as reference points for geodesic surveys and computers to speed up the recording and processing of survey data. The use of the Global Positioning System (GPS). as well as of Light Detection and Ranging (LiDAR) 3D laser scanners have aided in surveying and measuring real estate.

2. RESEARCH AIM AND METHODOLOGY

The main aim and result of this part of the research are to present indicators and measurements for real estate investments in the process of gentrification.

i. Data sampling and review of available cases and their properties were selected areas for social analysis. Table 1 shows the review of the social area analysis (Colomb, 2007; Demény and Shorter, 1968; Lewis, 1966; Van Arsdol et al., 1958).
ii. Literature review; review of social area analyses.
iii. Location specification, historical background. Cartographical data were gathered from many sources. For heritage buildings, I visited the homepage of www.vilagorokseg.hu. For presenting historical maps, the Arcanum Digital Database was used. Historical property terrier data were gathered from the Hungaricana Digital Database.
iv. New statistical results were obtained through the use of a Decision Tree and an Artificial Neural Network Analysis. An online database, www.ingatlan.com, offers survey information on the condition of building resources.
v. Presentation of diverse case studies.

2.1. Data sampling

Benchmark instruments have existed for centuries in many forms. Real estate surveys have traditionally used triangulation with the Ordnance Survey Benchmarks (BMs) as reference points for establishing ground heights (Fig. 1). This uses four classes of marks:

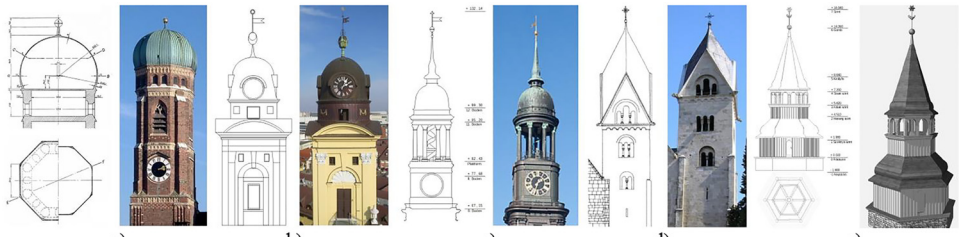


Fig. 1. a) 1st oder, München SO-1, Frauenkirche nördl. Kirchturm, TP-Nr. 002 44. (Null-Ablotepunkt, Knopf Mitte). b) 1st order, Debrecen, Great Protestant Church, Eastern spire, TP-Nr. 69-2001. c) 2nd order, Hamburg, St Michaelis Kirche, TP-Nr. 3/2425. d) 3rd order, Lébény, St James Benedictine Abbey-Church; Leiden, Southern spire, TP-Nr. 72-4012D. e) 4th order, Radostyán, Belfry, TP-Nr. 88-1119

first-order marks (FBMs) of high accuracy, usually anchored to solid rock and securely protected
second-order marks established on stable structures
third-order marks cut into walls and houses
fourth-order marks are used to subdivide an area within a third-order network.

2.2. Goodwill value of heritage properties

Article 7 of Act LXIV of 2001 regulates the protection of the built heritage and defines 'heritage asset'. In order to have heritage value, the asset must be an element of the built heritage, as well as of any natural territories, groups or systems related to these elements, and it must embody a historical, scientific, artistic, or technical monument of primary significance with regard to the past and its affiliation with a local community. It may include any type of sub-components, equipment, or contents. The goodwill value of heritage assets can be calculated by adjusting the correction coefficient of the replacement value of the property. The definition of heritage value and goodwill value requires the services of a heritage expert with the appropriate qualification and relevant practice in the field. In addition to the bases of value set out in VPS 3 of the RICS Red Book, the valuer is required to provide a valuation based on the 'value category' as used in Hungarian legislation. The so-called Red Book – the RICS appraisal and valuation manual – was originally published as a set of guidance notes on the valuation of assets. The 1st edition (1976), was published under the title *Statement of Asset Valuation Practice and Guidance Note*. The 2012 edition of the RICS Valuation – *Professional Standards* was published in March 2012 and RICS Hungary has also published the National Association Valuation Standards in Hungarian translation in 2012.

2.3. Location of heritage real estate management

UNESCO World Heritage sites in Hungary were first inscribed on the list at the 11th Session of the World Heritage Committee held in Paris, France in 1987. This extended to areas in Budapest including the Banks of the Danube, the Buda Castle Quarter, and Andrássy Avenue and its listed buildings (Fig. 2), UNESCO guidelines define three different aspects for examining the conditions of integrity. It requires an assessment of the extent to which the property

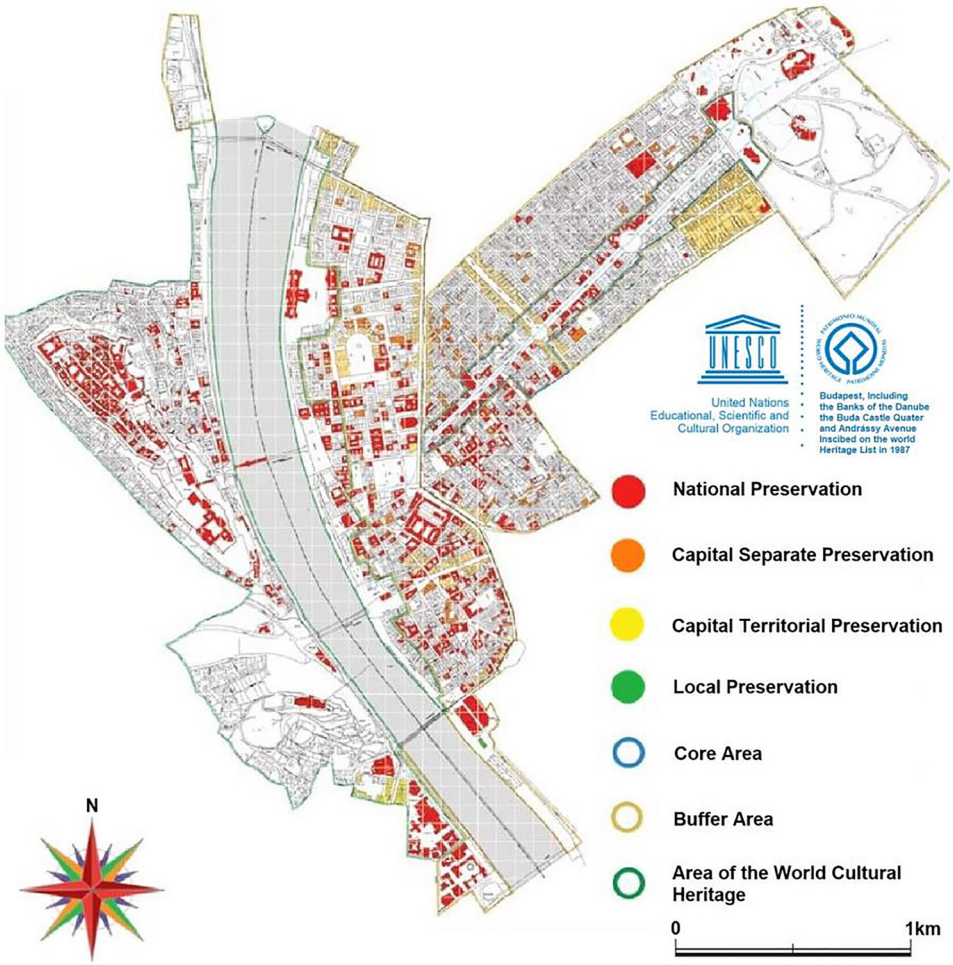


Fig. 2. Budapest world heritage zone and its listed buildings (*Source:* vilagorokseg.hu; ed.: author).

– includes all elements necessary to express its outstanding universal value;
– is of adequate size to ensure the complete representation of the features and processes which convey the property's significance;
– suffers from adverse effects of development and/or neglect. Integrity is a measure of wholeness and intactness of the natural and/or cultural heritage and its attributes.

2.4. Historical background and literature review of gentrification

Beginning with the fundamental contributions of J.H. von Thünen (*Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie,* I. 1826, II. 1850, III. 1860), A. Weber (*Reine Theorie des Standorts*, 1909), W. Christaller (*Central Places in Southern Germany*, 1933),

G.K. Myrdal (*Monetary Equilibrium*, 1939), A. Lösch (*The Economics of Location*, 1940) and later of the well-established model of W. Alonso (*Location and Land Use: Towards a General Theory of Land Rent*, 1964), R.F. Muth (*Cities and Housing*, 1969) and E.S. Mills (*An Aggregative Model of Resource Allocation in a Metropolitan Area*, 1967), urban economics has mainly considered generated land rent in terms of the demand for accessibility (Fig. 3). The two most important aspects of monocentricity/polycentricity are:

i) its morphological dimension, which denotes the size and spatial distribution of centres (Gál and Unger, 2009; Kadar and Vitkova, 2019; Locsmándi et al., 2000; Mészáros, 2000; Mills and MacKinnon, 1973; Nyitray, 1992; Ring, 2014),
ii) its five functional dimensions (commercial, manufacturing, residential, agricultural, waste), which additionally address the linkage between centres such as the daily flow of commuting people and social network connections (Alföldi, 2011; Baross and Struyk, 1993; Dúll, 1996; Lepel, 2010; Riedel and Ábel, 2018; Róka-Madarász, 2012).

The AMM model defines rent as the remainder left when the entrepreneur has subtracted production costs (including transportation costs) and a desired level of profit from the revenue obtained by selling the good. The Prime Value Intersection (PVI) is the place in the Central Business District with the highest land rent value. Formally, rent is expressed as $(d_0)r_i = (p_x - \pi - c(d_0))x(d_0)$ where

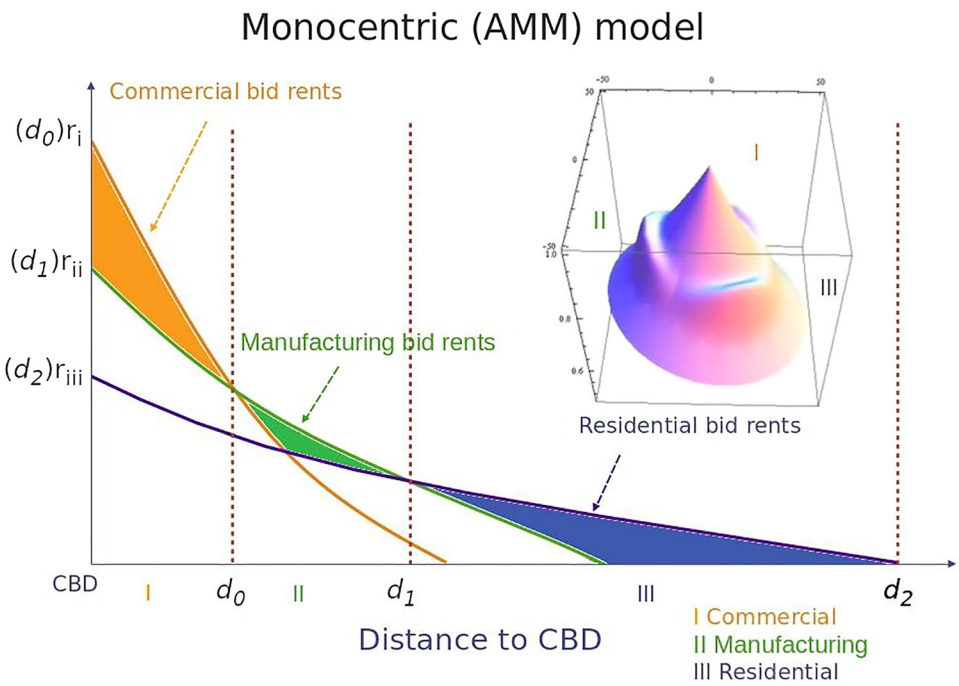


Fig. 3. Monocentric Alonso-Muth-Mills (AMM) model, Polycentric 3D bid rent function, R. J. Brown, 2011, ed.: author

r_i, r_{ii}, r_{iii},… r_n denotes the rent,
p_x the unit price of the good produced by the entrepreneur,
c the production costs per unit of land (including transportation costs) at a distance
d_0, d_1, d_2,… d_n from the city center CBD,
π the profit per unit of land, and
x the quantity of the good produced per unit of land at a distance from the city center.

Offices and shops can afford to pay higher rents in city centres than in industry or housing, so they tend to occupy the central ring. Researchers now argue that the construction of luxury apartment developments in city centres is a form of gentrification (Smith, 1996). The resulting architectural and spatial renewal causes social displacement type changes in the retail/consumption of services and the rise of property values in the nearby neighbourhoods (Dixon et al., 2003). During the era of socialism, the housing market in the cities of central and eastern European countries was controlled by the national administrations. During this period little maintenance of the building stock took place (Baross, 1987). Since then, liberalization of the housing market has meant almost complete deregulation in these countries (Brade et al., 2009). The privatization of ownership, including housing and land, was a key part of that process.

In Germany, with the Unification Treaty (Einigungsvertrag) a legal right was given to the original owners to claim their confiscated property (Krüger and Henderson, 1997). After reunification, Berlin's District 01-Mitte has been the area that most radically changed, as its central position in the united Berlin made it attractive to investors (Chr, 2004). Friedrichstraße is one of Berlin's most exclusive and expensive areas, with high-end retail and offices. In this area Friedrichstraße crosses Unter den Linden, the magnificent boulevard lined on both sides with monumental, centuries-old period buildings, including the State Opera. Table 1 shows the review of social area analysis in Berlin and some other countries.

3. THE HISTORY OF BUILDING ANDRÁSSY AVENUE IN BUDAPEST

All types of historic boulevards and avenues share a centuries-long history.

3.1. Erlangen: Universitätsstraße

Christian Ernst, a member of the House of Hohenzollern and Margrave of Brandenburg-Bayreuth, commissioned the architect Johann Moritz Richter to plan the Neu-Sadt area of Erlangen in 1686. It may fairly be assumed that the concept of the "Richter'sche Plan" was delivered by the first Huguenots from Vitry-le-François. In the plan there is a square, the 'Grande Place' (Schlossplatz), a double of the 'Place devant le Temple et la Douane' (Hugenottenplatz) (Fig. 4).

The street's width and length (in Fuß) followed the golden ratio:
'principale Rue' (Hauptstraße) symmetry axis, w:50F,
'grande Rue' (Ringstrasse), w:40F,
'Rue' (Straßen), w:25 F,
'Ruelle pour entrer dans les basses cours' [alley to enter the lower courtyards] (Gassen), w:20 F (Wüst et al., 2002).

The Neo-Renaissance apartment buildings around the 'rondell' at the intersection of Frauenklinikstraße (Universitätsstraße) and Kasernstraße (today Bismarckstraße) were built

Table 1. Social area analysis: selected studies

Social Area Analysis		
Country	**City**	**Study**
USA	Los Angeles	Shevky, Williams (1949)
	San Francisco	Shevky, Bell (1955)
	Chicago, Michigan	Hawley, Duncan (1956)
	Akron, Ohio; Atlanta, Georgia; Birmingham, Alabama; Kansas City, Missouri; Louisville Providence, Rhode Island; Rochester, New York; Seattle, Washington	Van Arsdol, Camilleri, Schmid (1958)
	Dayton Indianapolis Syracuse	Anderson, Egeland (1961)
UK	London Newcastle-under-Lyme	Herbert (1967), Harvey (1973) Atkinson (2000)
Turkey	Istanbul	Demény, Shorter (1968)
Australia	Melbourne	Jones (1969)
	Newcastle	Parkers (1972)
Canada	Winnipeg	Herbert (1972)
Italy	Rome	McElrath (1972)
Hungary	Budapest	Kovács, Wießner (1995)
Czech R.	Prague	Sykora (1996)
Poland	Cracow	Węcławowicz (1996)
	Warsaw	Gorzelák (1998)
Germany	Berlin	Häußermann, Kapphan (1998)
	Leipzig	Aring, Herfert (2001)
Russia	Moscow	Lentz (1999), Gdaniec (2005)
	St. Petersburg	Rudolp, Aksenov (2003)
Slovakia	Bratislava, Kassa	Ondoš, Korec (2006)

between 1890 and 1895. Until the inauguration of the monument in honor of Kaiser Wilhelm I, the square was simply called 'Rondell' and from 1897 Kaiser-Wilhelm-Platz (today Lorlebergplatz).

3.2. Berlin: Leipziger Straße

As part of the Berlin fortress, Liepziger Square, with the shape of an octagon and initially also officially referred to as 'Octogon', was developed together with the square, Pariser Platz, alias 'Quareé' and the circular, Belle Alliance Square, alias 'Rondell', (since 1947 Mehringplatz),

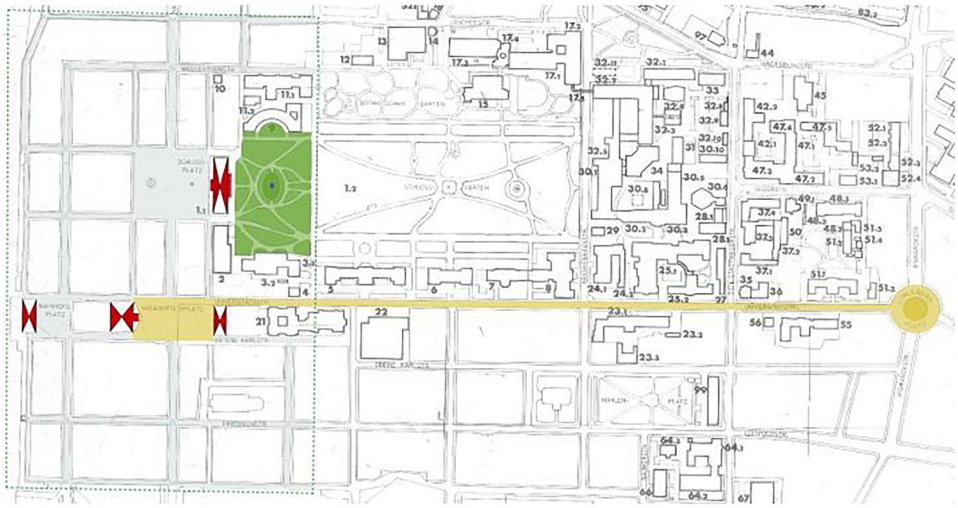


Fig. 4. Inner city (Inneres Stadtgebiet), ed.: author

following plans by Philipp Gerlach. The surrounding avenues, Leipziger Straße, Unter den Linden and Friedrich Straße, were developed with prestigious residential, administrative, and retail buildings.

3.3. London: Regent Street

After the Great Fire of 1666, the plan for Regent Street was the first urban renewal in the medieval inner city of London. The layout of Regent Street remains the same to this day as the architect John Nash designed it, and it has three significant points along its length, Langham Place, Oxford Circus and Piccadilly Circus. Regent Street and Regent's Park were conceived at a time when ideas were influenced by Haussmann's successes in Paris. When Mary-le-Bone Park, the royal hunting ground, reverted to the Crown in 1810, the Prince Regent (later King George IV) commissioned Nash to design a connecting ceremonial road from Carlton House to Regent's Park via Regent Street. Despite the desire to rival the Parisian avenues, Nash soon realised that land acquisition (e.g. impossible to acquire Langham House) and the social characteristics of the areas through which such an avenue would run, ruled out building a straight road. Nash's plan was presented to the House of Commons as a street proposed to run from Charing Cross to Portland Place, leading to the Crown Estate in Mary-le-Bone Park, and was accepted on 28th January 1813.

3.4. Paris: Champs-Elysées

During the period known as the Second Empire (1852-70), France was ruled by Napoleon III. During times of conflict and political revolts (1789, 1830, 1848), urban mobs would frequently blockade the maze that was the streets of Paris, and the crooked narrow lanes of the medieval city also played a role in such events. Napoleon III dreamed of a new, imperial city whose very

streets would speak of the glory of the French empire. He instructed Baron Georges-Eugene Haussmann, prefect of Seine, to modernize Paris. The emperor gave him the mission of making the city healthier and grander. He looked back to Louis XIV's Grande Epoque for the Baroque planning scheme of plazas, radial avenues, and junctions, like the Champs-Elysees and the Avenue de l'Opera linked to Rue de Rivoli. 'Une étoile', a star, was created around the Arc de Triomphe on the western side of Paris.

3.5. Budapest: Andrássy Avenue

The first plan for the construction of the new avenue was agreed upon by the House of Representatives in 1870 upon the proposal of Prime Minister Count Gyula Andrássy senior. This dynamic era brought an American-style development to Budapest and the capital became a modern European metropolis. The Municipal Board of Public Works (BoPW) (Fővárosi Közmunkák Tanácsa) was established in 1870 with Andrássy following the example of a similar board in London in 1855. In 1871 an international competition was organized for a city plan including a layout of radial avenues and circular boulevards and squares, and the location of public buildings. The first prize went to Lajos Lechner, chief engineer of the Ministry of Public Works and Transportation. The second prize went to the architects Frigyes Feszl & Co. and the third prize to Klein and Fraser from London. The new avenue was opened in 1876, and these Neo-Renaissance style buildings were finished in 1885. The avenue was named after Count Gyula Andrássy. Until Andrássy Avenue was built, Zsigmond Madarász's family lived at No. 61 Váczi út which was the corner house at the intersection of Könyök and Váczi út (currently 13 Bajcsy Zsilinszky út). Because of its spatial situation, the Madarász' site of 506 □° square-fathoms (ftm^2) was the most unusually shaped site along the avenue (Mezősné Szilágyi, 2014). The plot, ending in an acute angle, suggested putting the emphasis on the endpoint of the trapezoid shape. The corner site provided the opportunity for having two main facades – a circumstance that could inspire architectural experimentation (Preisich, 1998). Besides the President, Count Andrássy, Frigyes Podmaniczky was appointed as Vice-President of the Board of Public Works (BoPW). Podmaniczky proposed Miklós Ybl and István Linzbauer produce the study plans for the most important sites of the new avenue. István Linzbauer's plan of the Opera House for the Madarász site was strongly influenced by Semper's Opera House in Dresden. The following plots were selected as possible locations for the Opera House (Dalműszínház):

Zsigmond Madarász's plot
Karl's Barracks
Wodianer site
Hermina Square

In the end, the Opera House was built on an empty public plot – the lowest-priced plot – on Hermina Square using the plans by Miklós Ybl (Józsa, 2016). The construction of the avenue and the demolition of buildings started in 1872, but in the following year, on Black Friday 9th May 1873, only eight days after the opening ceremony of the Vienna EXPO, Vienna's stock exchange crashed and the financial crisis caused significant interruption to the works. Buda, the old capital of Hungary, and Óbuda were officially united with Pest, and a new metropolis, Budapest, was born in November 1873 (Preisich, 1998). The construction work dragged on from 1873 to 1876. By 1876 a mere forty houses had been completed, several of them as investments by the Avenue Corporation. The construction work and the wooden cube road surface were

partially finished for the opening ceremony of the avenue held on 20th August 1876. From 1879 onwards, the building industry started booming again and the number of buildings continued to go up. The 'Pest Insurance Company' merged with the Belgian 'Fonciére Insurance Company' in 1879. They chose the Madarász site on the first plot of the 'Radial Avenue' and decided to build a new luxury residential tenament house, the main purpose being to advertise the firm's strength. The site was successfully purchased for 253.415 Forints – a costly price at the time. For comparison, 3.6 square meters cost 500.82 Forints at the corner of Váczi Boulevard and the same unit would have been less than 30 Forints near the City Park (Ahlfeldt, 2013). The task of designing the buildings lining the new avenue was assigned to various famous architects, amongst them Ödön Lechner. Lechner was an outstanding master in the history of Hungarian national architecture and laid the foundations for a specifically Hungarian version of 'secessionist' art (Art Nouveau). In 1899 he started a study-tour of Europe with his best friend, Vilmos Zsolnay, the founder of the Zsolnay Ceramics Works which is still in operation at Pécs. In London, he studied Persian and Indian art at the Kensington Museum and the achievements of modern urbanistics. These trips had a major influence on his later work. The first time he applied both oriental and Hungarian folk art motifs and utilized the pyrogranite and majolica produced by Zsolnay was in the plans for the Museum of Applied Arts, completed in 1896. The Museum is the first mature example of the non-Historicist style and the advent of nationally inspired secessionist architecture. This building was the first opportunity for Lechner to realise completely his own architectural and artistic ideas. His architectural conceptions essentially remained based on eclecticism, and his ornamentation relied increasingly on the treasure trove of Hungarian folk art. This was realised and embodied in the building of the Royal Hungarian Geophysical Institute, in the Drechsler Palace on Andrássy Avenue (the Hungarian Railway Pensioners' Building designed together with Gyula Pártos), in the Church of St. Elisabeth – the "Blue Church", in the Thonet House, and in Gyula Lechner's House at 40 Bartók Béla Street.

Emil Gyula Unger, Mihály Pollack's grandson, had graduated from the Bauakademie [Academy of Architecture] of Berlin and returned to Pest. He worked with Miklós Ybl at the architectural office of the Hungarian Academy of Sciences and later at the Sugárút/Radialstrasse Bauunternehmung (Radial Avenue Construction Company) as a chief architect. The first building permit in August 1872 was issued for a block called Seven Houses to be built at the corner of Nagymező and Jókai (Gyár) Street (Preisich, 1998). The cluster of plots 32-44, comprising three five-storey and four four-storey buildings, was designed by Emil Unger. The Madarász Villa was the first studio type house around Andrássy Avenue before the buildings of the Epreskert (Strawberry Garden) Art Colony. Sadly, the plans for the Madarász Villa haven't survived, so we know little about this studio cum painter's home and can only imagine the way it must have looked based on the one available photo kept in the Photo Archives of the Hungarian National Gallery. In 1869 Madarász acquired a 599 ¼ □° square-fathom plot for 6.000 Forints at Városligeti alley 27 (Fig. 5). Madarász commissioned Károly Hild to build an atelier-villa following the plans of architect E. Gy. Unger. It can fairly be assumed that the architect was Unger, as mentioned by E. Gábor (Gábor, 2007). The Madarász Villa had a symmetrical layout with a tripartite façade and a unique arch in the middle. The triumphal arch is rather rare in the Hungarian architecture of the age, but we can see similar examples in the Wechselmann villa and the great pavilions to the side of Várkert Bazaar. This motif alludes both to the Italian cinquecento and French revolutionary architecture. According to E. Gábor, the facade is similar to Claude-Nicolas Ledoux's Tabary pavilion in Paris from the end of the 18th century (Gábor, 2007).

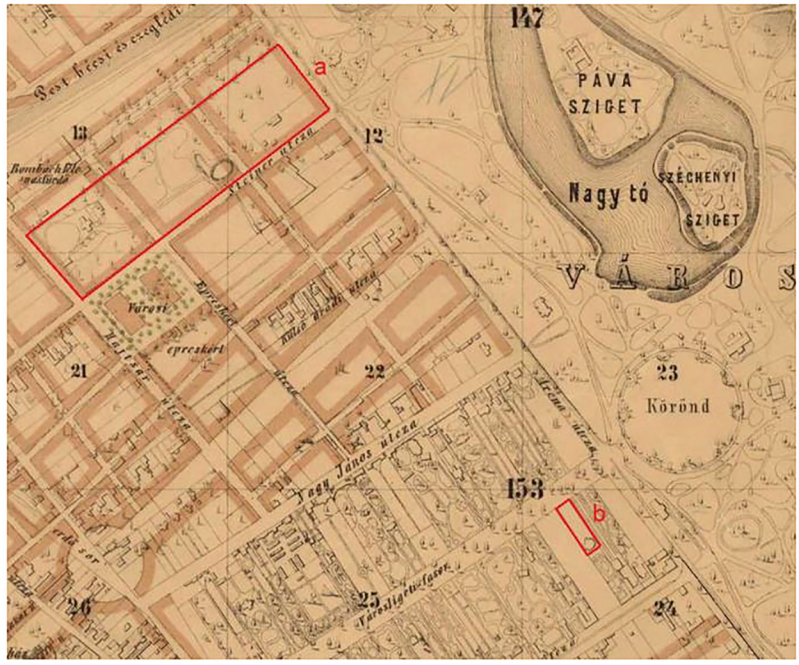


Fig. 5. Halácsy Map in 1873 a) Zsigmond Madarász's plot at Városliget, Arena Str. Grundbuch: V. 139-144 grape, b) Viktor Madarász's plot at 27 Városligeti fasor, and the newly built studio (today 45 Városligeti fasor)

At the turn of the 19th century, the urbanisation of Budapest shifted to outer Teréz Town. The growing population required the construction of educational facilities. Two schools were built on Zsigmond Madarász's site – the elementary school at Bajza street following plans by architect Rezső Ray and a secondary school following plans by architect Kálmán Kőrössy. The grammar school was named after Ferenc Kölcsey, the author of the Hungarian national prayer and anthem, the *Hymn* [Himnusz]. The closest counterpart in Hungary was the Budapest Royal Hungarian State Institute for Model Drawing, which was later elevated to the rank of The Hungarian University of Fine Arts at 69-71 Andrássy út.

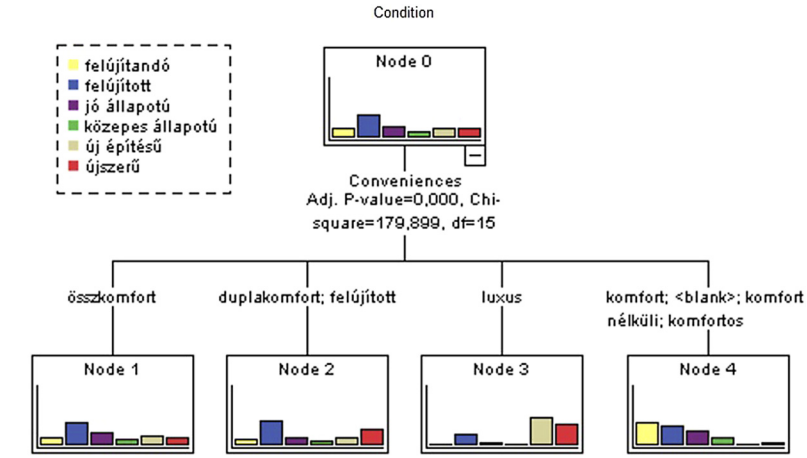
4. NEW RESULTS AND CASE STUDIES

4.1. Andrássy/Hübner-court

The former Andrássy Court of what was originally termed 'the Körönd' was designed following the plans of architect Gyula Bukovics and was built in 1885. From 1924 until his death in 1967 composer Zoltán Kodály and his family lived in this building, which came to be named after him. The renovation project of the Kodály House, located on what came to be called Kodály Circus, was financed by an international property developer. This project had a significant

impact on raising the mean supply prices in the local property market around (Kutasi, 2016; Róka-Madarász and Mályusz, 2013; Róka-Madarász, 2021) in 2010. Property data were analysed using a tool called Statistical Package for the Social Sciences. All modelling functions are available in the end-user environment which offers the opportunity of programming in syntax. Decision Tree classification was used to predict a maximum Tree Depth in the 2-level CHAID tree with a total of 5 nodes, of which one root parent node contains all at level 0, and of which 4 were terminal child nodes at level 1 with the Depth being 1. The major variable 'Condition' ($p_x(i) = 0.000$, Chi-square = 179,899, with Bonferroni correction on the p-value, $\alpha = 0.05$), reached significance for 'Conveniences' (Fig. 6).

In the Artificial Neural Network Analysis (ANNA) a 70-30 partitioning was used, with 70% of the data set for training and 30% for testing; training time being 00:00:02,833. Multi-layer, in this case, three-layer, perceptron (TLP) 9-5-6 neurons feedforward network architecture was used with one hidden layer. For the hidden layer, the hyperbolic tangent activation function was used, where the chain rule was employed to backpropagate. The Input Layer (Link) contains a 'Conveniences' factor and a 'Price/m2' covariate. The Output Layer (Right) contains 'Condition' as a dependent variable with a softmax activation function $\sigma : \mathbb{R}^K \to [0,1]^K$. The choice for cost function includes the use of a cross-entropy error that may minimize loss, for the j^{th} element of class according to the weight vector $P(y = j|x) = \frac{e^{x^T w_j}}{\sum e^{x^T w_k}}$ and bias in the network (Kádas and Klafszky, 1976); see Fig. 7. The online




```
* Decision Tree.
TREE Condition [n] BY Conveniences [n]
  /TREE DISPLAY=TOPDOWN NODES=CHART BRANCHSTATISTICS=YES NODEDEFS=YES SCALE=AUTO
  /DEPCATEGORIES USEVALUES=[VALID]
  /PRINT MODELSUMMARY CLASSIFICATION RISK
  /METHOD TYPE=CHAID
  /GROWTHLIMIT MAXDEPTH=AUTO MINPARENTSIZE=100 MINCHILDSIZE=50
  /VALIDATION TYPE=NONE OUTPUT=BOTHSAMPLES
  /CHAID ALPHASPLIT=0.05 ALPHAMERGE=0.05 SPLITMERGED=NO CHISQUARE=PEARSON CONVERGE=0.001
    MAXITERATIONS=100 ADJUST=BONFERRONI
  /COSTS EQUAL
  /MISSING NOMINALMISSING=MISSING.
```

Fig. 6. Decision tree relation with conditions

Network Information

Input Layer	Factors	1	Conveniences
	Covariates	1	Price/m2
	Number of Units[a]		9
	Rescaling Method for Covariates		Standardized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		5
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	Condition
	Number of Units		6
	Activation Function		Softmax
	Error Function		Cross-entropy

a. Excluding the bias unit

Fig. 7. Network information and syntax of the multi-layer ANNA

property database classifies the conveniences of the units as follows: total, double, luxury, or without conveniences. The database classifies the condition as follows: in bad condition, renovated, in good condition, in medium condition, newly built, andin near-new condition (Róka-Madarász and Mályusz, 2013).

Hübner Court, a French neo-renaissance style *cour d'honneur* building was a commission executed by contractor Nándor Hübner in 1883 and built after the plans, once more, of architect Gyula Bukovics at No. 4. Körönd. The Circus was originally decorated with fountains and planted with horse-chestnut trees. King Franz Joseph made a gift of ten statues to the capital at the beginning of the 20th century. One of these stands at the Körönd, the statue of Miklós Zrínyi (by József Róna 1902). The building, due to its history and special features is an unrepeatable masterpiece where each aspect serves a greater purpose that is more important than the individual piece, both as regards the environment in which it is built and the individuals who are to live in it. The architectural documentation was created by Bálint Nagy's studio N&n Ltd., later known as Studio KVARC Ltd. As of 2022, the Hübner Court at 92-94 Andrássy Avenue offers new living spaces, while it continues to reflect faithfully its historical heritage. The property, with its rich historical and cultural legacy, has been refurbished in a new, elegant neo-renaissance style, thanks to state-of-the-art innovative technologies and outstanding engineering expertise, and is on its way to becoming a real jewel in its lively surroundings. A sum of 17 individual and unique rooftop luxury apartments boast an internal two-storey structure incorporating the corner-towers (Fig. 8).

4.2. Wahrmann Palace

Wahrmann Palace, in Lower Teréz Town at 23 Andrássy Avenue, was built in 1884 in a neo-renaissance style following the plans of architect Vilmos Freund. This listed building was renovated in 2006 according to plans by architects Tamás Kőnig DLA and Péter Wagner DLA (Wagner, 2012), experts whose entire architectural oeuvre and teaching approach are highly authentic and set a good example in the profession.

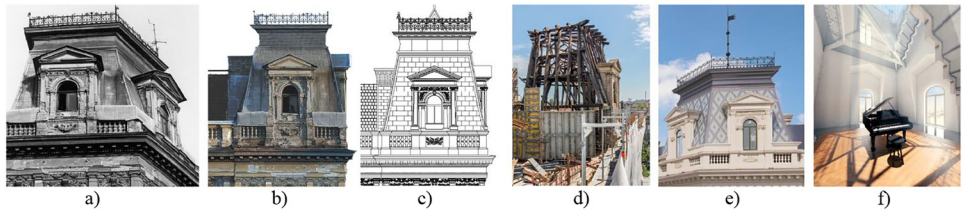


Fig. 8. Renovation of the Hübner corner-towers. a) Photo by Edit Szilágyi (VI-73-1), 1965. b) Orthophoto in 2001. c) Drawings by N&n in 2002. d) Under construction in 2021. e) f) 3D model of the two-storey tower by studiokvarc.hu

Scenario A – Residential function.

The first concept of the Spanish property investor was to save the original residential function of the building, especially the Wahrmann's apartment on the piano nobile, so the plans contained luxury living rooms with recreation areas, and a pool on the subterrene.

Scenario B – Commercial – Office/Retail function.

True to the second set of plans for the house, it is currently functioning as an office building offering a 2,500 m^2 lettable area. Retail shops for luxury brands operate on the ground floor (Collins and Morsányi, 2001). In 2010 the architects earned an ICOMOS award for this reconstruction.

Table 2 shows investment intensity in three areas of Andrássy Avenue and in the City Park.

5. DISCUSSION AND CONCLUSION

The last three decades have seen Budapest regenerate in a number of different ways. The most important operations have taken place in the inner city (Belváros). As regards the study of the built environment, real estate research is dominated by an interest in commercial properties, including studies on offices, retail establishments, and hotels. Further research has looked into the functioning, among others, of residential, educational (school, academic), cultural (museum, theatre), manufacturing, healthcare (hospital, clinic), church, and institutional facilities (authorities, diplomatic establishments). Research has found that the area of the Andrássy Avenue world heritage core zone of Budapest was affected by gentrification progressing both in space and time, increasing with each location as one moves step by step further from the city center.

Table 2. Renovation and investment intensity in the research areas

Investment	Lower Teréz Town	Pest "Broadway"	Outer Teréz Town	City Park
Date	1990-	2000-	2010-	2020-
Capital	Large	small	medium	small
Government	Small	large	medium	large
Residents'	Small	medium	small	small

According to the literature, in the life-cycle of listed heritage properties with goodwill value, a maintenance phase should be included and this should constitute the longest or a never-ending section of their life-cycle.

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