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ÇOK KRİTERLİ KARAR VERME YÖNTEMLERİYLE EMLAK FİYATLARI VE KONUTA ERİŞEBİLİRLİK AÇISINDAN ŞEHİR KARŞILAŞTIRMALARI

CITY COMPARISONS IN TERMS OF PROPERTY PRICES AND HOUSING AFFORDABILITY THROUGH MULTI-CRITERIA DECISION-MAKING METHODS

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ÖZ

Özellikle pandemi döneminin başlangıcından itibaren dünya genelinde emlak fiyatlarının hızla artmasıyla birlikte düşük ve orta gelirli milyonlarca insan kira ve konut fiyatları nedeniyle önemli sorunlar yaşamaktadır. Buna bağlı olarak, gelirlerinin önemli bir kısmını kira ya da konut kredisine ayırmaları gerekmektedir. Konut kira ve satın alma fiyatları, ortalama aile gelirine göre daha hızlı artmaktadır. 17 Sürdürülebilir Kalkınma Hedefi'nin ve 169 ilgili hedefin çoğu, konutla diğer başlıklara göre daha fazla bağlantılıdır. Hükümetler, Sürdürülebilir Kalkınma Hedeflerini destekleyen politikalar aracılığıyla tüm bireylerin sosyal, ekonomik ve ekolojik olarak sürdürülebilir toplu-luklarda yeterli ve uygun fiyatlı konutlara erişebildiği ve herkesin tam potansiyeline ulaşabileceği bir ortam sağlamalıdır. Çalışma, konut satın alınabilirliği ve emlak fi-yatlarının performansını ölçmede kullanılan göstergelerin sistematik olarak nasıl analiz edileceğine dair ve karşılaştırma yapabilmek için küme analizi ve çok kriterli karar verme yöntemlerinden oluşan yeni ve özgün bir bütünleşik yaklaşım önermektedir. Gösterge ağırlıkları Critic yöntemi ile objektif olarak belirlendikten sonra 25 ülkeden 60 şehir TOPSIS, VIKOR, PROMETHEE I-II, ARAS, COPRAS, ELECTRE, SAW ve MAUT yöntemleri ile karşılaştırılmıştır. Ayrıca Borda Sayım

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Metodu ile genel bir ortak sıralama elde edilmiştir. Ayrıca ülkeler ve şehirler bazında değerlendirmeler ve karşılaştırmalar yapılmaktadır.

Anahtar Kelimeler: *Emlak piyasası, erişebilir konut, kentsel eşitsizlik, sürdürülebilir kalkınma hedefleri, ÇKKV.*

ABSTRACT

Especially since the beginning of the pandemic period, millions of people with low and middle incomes are experiencing significant problems due to the rapid increase in real estate prices worldwide. Therefore, they have to allocate a significant portion of their income to rent or housing loans. The price of renting and purchasing a home is increasing faster than the average family income. Many of the 17 SDGs and 169 related objectives have a greater connection to housing than others. Governments should provide an environment where all individuals have access to adequate and affordable housing in socially, economically and ecologically sustainable communities, and where everyone can reach their full potential, through policies that support the Sustainable Development Goals. This study proposes a new and original integrated approach consisting of cluster analysis and multi-criteria decision-making methods to systematically analyze indicators and compare the performance of housing affordability and property prices in cities. After determining the indicator weights objectively with the Critic method, 60 cities from 25 countries are compared with TOPSIS, VIKOR, PROMETHEE I-II, ARAS, COPRAS, ELECTRE, SAW and MAUT methods. Also, a general common ranking was obtained with the Borda Count Method. In addition, evaluations and comparisons are made in terms of countries and cities.

Keywords: *Property market, affordable housing, urban inequality, sustainable development goals, MCDM.*

1. Introduction

Due to economic growth and population expansions around the globe, getting a property has become increasingly tough for especially low and medium-income households in many nations (Galster & Lee, 2021). During the pandemic period, a significant increase in the price of the real estate has been recorded in numerous metropolitan cities across the globe. Housing rents and prices are increasing at a higher rate than the increase in average family income. An increasing number of individuals living in cities, notably those with lower incomes, have been required to pay greater proportions of their income for the housing rent or mortgage credit. Many governments are working hard to guarantee that their residents have access to affordable housing. On the other hand, according to a recent report by the International Monetary Fund (IMF), housing strategies of governments in many countries have not been successful (Fields & Hodkinson, 2018; Samarasinghe, 2021). There are several threats to cities, regions, and society at large due to a shortage of affordable housing. A lack of housing costs European economies 195 billion euros each year, according to Eurofound. In Europe, one in ten people spends more than 40% of their income on housing-related costs. It is clear that governments and policymakers can no longer brush over the human and financial costs of this policy failure or in certain instances a policy vacuum by leaving it up to the market. Many of the 17 SDGs and 169 related objectives have a greater connection to housing than others. Governments should provide an environment where everyone has access to adequate and affordable housing in socially, economically and ecologically sustainable communities, and where everyone can reach their full potential, through policies that support the Sustainable Development Goals (Europe, 2017).

Housing is actually considered a fundamental right for all people. It is one of the most important elements that meet the need of shelter, which is one of the basic physical needs of the individual, and that people need to live in a safe and comfortable way. Also, it is the subject of a wide and diverse background of different experts in the fields of planning, financing, design, sociological research, anthropology, anthropometry, hygiene, construction, technology, management and maintenance (Almusaed & Almssad, 2018). Housing cannot be expressed only as a commodity, if it is considered in a social framework, it is a concept that has social, economic, political and physical content for the society. The cost of housing and problems with finding affordable housing can affect the budget of a family, resulting in leaving less money for food, utilities, transportation to work, health care, and child care. It also causes less money to be set aside for emergencies, retirement and opportunities like going to college or starting a small business. Therefore, these problems could lead to fewer chances and a worse standard of living in general (Anacker, 2019).

Also, the housing market has a fundamental role in economic development and poverty reduction. For policies in this sector to make a difference, they must be well-organized, evidence-based, and capable of responding to demands and real needs as well as social issues related to housing (Un-Habitat & Programme, 2011). The housing market, together with the related sectors, is the most important field of activity for the construction sector and the construction materials industry, which is a driving force for the growth of the economy. The healthy functioning of the construction sector is important for the existence of financial stability. The feeling of stability and trust paves the way for the increase in the volume of housing investment and the revival of housing demand (Alaloul et al., 2021). Therefore, it is very important for policy makers to produce strategies and action plans related to this issue for the future of their nations.

The crisis of affordable housing has a number of negative effects on both individual households and the economy as a whole. A lot of research shows that families who have trouble paying for housing, especially their children, are more likely to have problems with their health, education, and jobs (Leventhal & Newman, 2010; Newman & Holupka, 2014). Also, it is clear that the lack of affordable housing leads to longer commutes and delays in starting families, getting married, and having children (Wrenn et al., 2019; Wu et al., 2019). On a larger scale, not being able to afford a house could have big and long-term effects on the economy as a whole, such as putting downward pressure on birth rates and environmental damage in cities. Unaffordable housing could also slow the growth and competitiveness of a metropolitan area by discouraging people and businesses from moving there. This misallocation of labor can slow economic growth at the national level (Hsieh & Moretti, 2019).

When the studies in the literature are reviewed, it is seen that the housing prices is related to many parameters such as population migration (Lin et al., 2018), national income (GDP) (Englund & Ioannides, 1997), foreign investment (Chen et al., 2021), current account deficit (Hepsen & Asici, 2013), housing loan volume (Jiang et al., 2018) and loan interest rates (Akkas & Sayilgan, 2015; Chen et al., 2021), exchange rate (Bahmani-Oskooee & Wu, 2018), inflation (Rehman et al., 2020) and construction costs (Chiwuzie & Dabara, 2021; Geng, 2018; Olanrewaju et al., 2018). Socio-economic stability of a country and growth may be gauged by its capacity to purchase housing. The goal of housing affordability is to guarantee that the housing offered can be afforded by all income groups, regardless of income level (Dawkins, 2021; Liu & Ong, 2021). However, on the other hand, housing prices in the world continue to rise. Worldwide, the value of an average home has increased by 10.3% in the 12 months to the fourth quarter of 2021. Figure 1 shows the impact of the pandemic on global house prices. The chart above presents the ratio of countries/regions by annual price increase. The chart below shows the annual % change in real global housing prices from Q1 2018 to Q4 2021 (Kate Everett-Allen, 2021).

Fifty-four of the 56 countries and regions tracked by the Knight Frank Index observed that prices increased year-on-year, while prices remained stable only in Malaysia and Morocco. In addition, the proportion of housing markets with price increases exceeding 10% per year among these 56 countries has increased from 13% at the beginning of the pandemic to 48% now (Kate Everett-Allen, 2021).

Figure 1: The ratio of countries/regions by annual price increase and the annual % change in real global housing prices from Q1 2018 to Q4 2021 (Kate Everett-Allen, 2021).

In nominal terms, Turkey is the nation where prices have risen the most, with prices going up by 108% in Q3 2021. This value is 127 percent as of the end of the first quarter of 2022. In addition, Turkey is the country with the highest inflation rate in Europe with 67 percent inflation as of the end of Q1 2022. When inflation is taken into account, Australia follows Turkey with a 17.5 percent price increase in real terms (Institute, 2012). Thus, it is likely that housing prices will continue to go up. In real terms, South Korea is the country where prices rose at the fastest rate each year from Q3 2020 to Q3 2021. Ninety-six per cent of markets have positive annual price growth (Kate Everett-Allen, 2021; Kim & Yook, 2021).

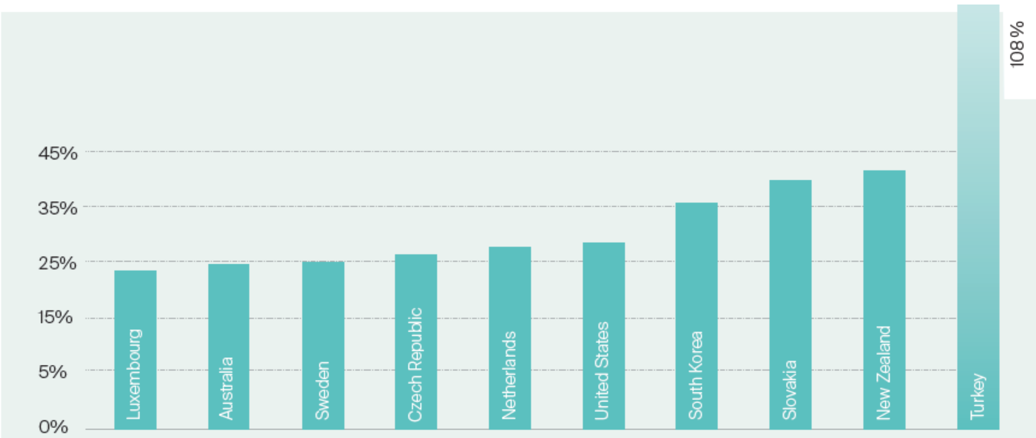

Figure 2: Highest property price risers since the start of the pandemic, top ten performing markets since Q4 2019 (Kate Everett-Allen, 2021).

When it comes to nominal or real prices, Turkey, New Zealand, the Czech Republic, Slovakia, and Australia are in the top five. In 2021, prices dropped in just three markets: Malaysia, Malta, and Morocco.

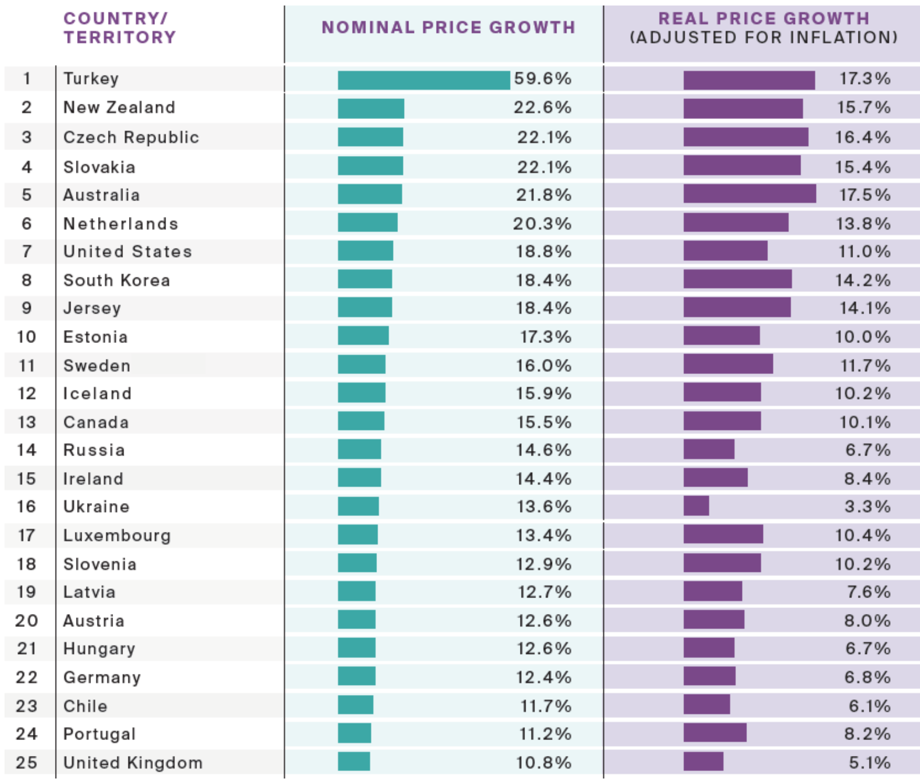

Figure 3: Ranking of Countries by Nominal % Annual Change, from Q4 2020 to 14rd Quarter 2021 (Kate Everett-Allen, 2021).

In the study, it is primarily aimed to draw attention to the housing market, which shows a very high price increase globally, with current data and to compare the important cities of the countries where this increase has been most experienced in terms of some related indicators and affordability. In the analysis part of the study, CRITIC, TOPSIS, VIKOR, ARAS, COPRAS, PROMETHEE II, SAW, MAUT, ELECTRE, Borda Count and Clustering methods are used. Indicator weights are obtained by the CRITIC method, one of the objective weighting methods. In the study, 60 cities from 25 countries with the highest price increase are compared by using 7 indicators, including price to income ratio, gross rental yield city centre, gross rental yield outside of centre, price to rent ratio city centre, price to rent ratio outside of city centre, mortgage as a percentage of income, and affordability index.

Some of the studies in the literature and their contents are as follows. The main purpose of Cheong and Li (2018) was to explore the transitional dynamics of housing affordability indicators of major cities in three developed countries: the USA, Canada and

Australia, in the period after the global financial crisis. Samarasinghe (2021) presented a comparative analysis, primarily focusing on comparing and contrasting affordable housing policies in Australia and New Zealand. Matoušek (2021) aimed to investigate disparities in affordability of own housing across regions of the Czech Republic Hurbánková (2021) aimed to analyse the regions of Slovakia using selected indicators related to housing. According to the results of the analysis, they found out that from the point of view of the analysed indicators the best were placed Trenčín, Nitra and Žilina regions, and the worst Košice and Prešov regions. By considering the rapid and continuous increase of housing prices in Turkey recently, Kartal, M. T., Kartal et al. (2021) aimed to examine the determinants of the residential property price index (RPPI). Saldaña-Márquez et al. (2019) presented a comparative analysis of the housing indicators used by the single-family housing rating systems, in which the residential urban environment influences buildings' certification scores, emphasizing the relationships of six systems developed by middle-income countries (MICs) and the two most-recognized rating systems. Soaring real estate prices and valuations despite the economic downturn brought by the pandemic have focussed the attention of Dutch policymakers on potential macro-financial and socio-economic implications. In this context, Luca and Geis (2021) reviews the salient features of Dutch commercial and residential real estate markets with an eye to identify pertinent risks and challenges. Emekci (2021) on the one hand aimed to examine how the pandemic has exacerbated the problem; on the other hand, the paper tried to reveal that the problem has been handled incorrectly and how weaknesses in the policy strategies contribute to this problem through a case study of the low-income group.

The remaining of the study is organized as follows: Section 2 explains analyzed cities, definitions of indicators, raw data and all the steps of the proposed MCDM methods. Section 3 presents obtained results. Section 4 presents discussions and Section 5 presents the conclusion.

2. Materials and Methods

This section explains methodology and raw data of the study. Utilizing the "Property Prices Index by City 2022" data, 40 cities from 25 nations with the largest real housing growth over the pandemic period were assessed in terms of 7 indicators using CRITIC-based TOPSIS, VIKOR, ARAS, COPRAS, PROMETHEE II, SAW, MAUT, and ELECTRE methodologies. The data utilized for the analyses were gathered from the Numbeo and World Bank databases. Information about the research cities is supplied in Table 1.

Table 1. Cities evaluated in the analyses

City, Country	Population	Density (per km^2)	City, Country	Population	Density (per km^2)
Adelaide, Australia	1,306 million	422	Melbourne, Australia	5,078 million	500
Amsterdam, Netherlands	821.752	4,908	Montreal, Canada	1,78 milyon	4,517
Ankara, Turkey	5,663 million	531	Munich, Germany	1,472 million	4,800
Antalya, Turkey	1,319 million	113	New York, USA	8,538 million	10,892
Auckland, New Zealand	1,657 million	1,210	Nizhny Novg., Russia	1,257 million	2,400
Berlin, Germany	3,645 million	4,112	Odessa, Ukraine	1,015 million	6,300
Birmingham, UK	1,149 million	4,200	Ottawa, Canada	994.837	317
Boston, USA	673.184	5,383	Perth, Australia	1,985 million	334
Bratislava, Slovakia	424.428	1,169	Philadelphia, USA	1,567 milion	4,514
Brisbane, Australia	2,28 million	346	Phoenix, USA	1,615 million	1,207
Budapest, Hungary	1,756 million	3,351	Prague, Czechia	1,309 million	4,600
Calgary, Canada	1,336 milyon	1,501	Reykjavik, Iceland	122.853	480
Chicago, USA	2,704 million	4,588	Riga, Latvia	632.614	2,000
Christchurch, N. Zealand	381.500	270	Rotterdam, Holland	623.652	3,043
Cologne, Germany	1,086 million	2,700	Saint Helier, Jersey	33.500	2,671
Dallas, USA	1,317 million	1,494	S. Petersburg, Russia	4,991 million	3,752
Dublin, Ireland	544.107	4,708	San Diego, USA	1,406 million	1,670
Edmonton, Canada	981.280	1,360	San Francisco, USA	870.887	7,174
Gothenburg, Sweden	579.281	1,300	Santiago, Chile	5,614 million	9,821
Hamburg, Germany	1,841 million	2,400	Seoul, South Korea	9,776 million	16,000
Houston, USA	2,303 million	1,483	Stockholm, Sweden	975.551	4,800
Istanbul, Turkey	15,46 million	2,839	Sydney, Australia	5,312 million	2,037
Izmir, Turkey	4,367 million	358	Tallinn, Estonia	426.538	2,800
Kiev, Ukraine	2,884 million	3,299	Den Haag, Holland	514.861	6,500
Lisbon, Portugal	504.718	8.699	Toronto, Canada	2,93 million	4,149
Ljubljana, Slovenia	279.631	1,712	Vancouver, Canada	675.218	5,400
London, United Kingdom	8,982 million	5,701	Vienna, Austria	1,897 million	4.631
Los Angeles, USA	3,976 million	3,276	Washington, USA	681.170	4,308
Luxembourg, Luxemb.	632.275	242	Winnipeg, Canada	749.534	1,430
Manchester, UK	553.230	12,210	Yekaterinburg, Russia	1,387 million	1,200

As shown in Table 1, 60 cities from 25 countries where the highest increase in housing prices were recorded during the pandemic period are analyzed and compared with the data of the 4th Quarter of 2021.

In the research, 7 indicators in the Property Prices Index by City 2022 were used in order to evaluate the purchasing power of housing. The information about these indicators used in the analyses is presented in Table 2. When comparing cities in the analyses, four of the indicators are expected to be maximum and three to be minimum in terms of indicator type.

Table 2. Indicators (Numbeo, 2022).

Indicator	Definition	Codes	Type
Price to Income Ratio	Price-to-income ratio is the ratio between the price of a median home to that of the median annual household income in a particular area.	C1	nonbenefical
Gross Rental Yield City Centre	It is the total gross rent collected from a property compared to the property market value or purchase price of a property in the city centre: Gross Yield = Gross Annual Rent / Current Market Value.	C2	benefical
Gross Rental Yield Outside of Centre	It is the total gross rent collected from a property compared to the property market value or purchase price of property outside the centre: Gross Yield = Gross Annual Rent / Current Market Value.	C3	benefical
Price to Rent Ratio City Centre	It compares the median home price in the city centre with the median annual rent.	C4	nonbenefical
Price to Rent Ratio Outside of City C	It compares the median home price outside the city centre with the median annual rent.	C5	nonbenefical
Mortgage As a Percentage of Income	The ratio of the mortgage payment (eg, principal, interest, taxes, and insurance) to monthly gross income.	C6	nonbenefical
Loan Affordability Index	It is an inverse of mortgage as percentage of income. Used formula is : (100 / mortgage as percentage of income)	C7	benefical

The raw data used in the analyses are shown in Table 3.

Table 3. Raw data used in analyzes (Numbeo, 2022)

City	C1	C2	C3	C4	C5	C6	C7
Adelaide	4.26	6.34	7.8	15.77	12.82	29.29	3.41
Amsterdam	10.06	4.17	4.63	24.01	21.59	60.05	1.67
Ankara	11.06	4.32	4.39	23.16	22.76	207.73	0.48
Antalya	9.77	5.07	5.37	19.72	18.62	163.02	0.61
Auckland	12.1	3.54	4.14	28.28	24.14	83.08	1.2
Berlin	9.42	3.45	3.75	28.99	26.64	56	1.79
Birmingham	7.77	4.72	5.91	21.17	16.92	51.49	1.94
Boston	8.24	4.75	5.8	21.05	17.25	55.71	1.79
Bratislava	14.56	3.41	3.6	29.34	27.8	82.09	1.22

Brisbane	6.34	4.73	5.25	21.15	19.04	43.54	2.3
Budapest	14.63	3.1	3.52	32.27	28.42	112.3	0.89
Calgary	3.66	7.29	7.89	13.71	12.68	23.26	4.3
Chicago	3.6	7.47	11.6	13.39	8.62	24.32	4.11
Christchurch	4.76	6.19	8.94	16.17	11.18	33.68	2.97
Cologne	10.09	3.31	3.45	30.18	28.96	63.07	1.59
Dallas	2.12	10.16	14.91	9.84	6.71	14.78	6.77
Dublin	8.11	6.01	8.01	16.63	12.48	54.84	1.82
Edmonton	3.52	6.69	8.61	14.94	11.62	22.44	4.46
Gothenburg	9.04	3.17	3.54	31.58	28.23	56.71	1.76
Hamburg	10.9	2.83	3.29	35.33	30.44	64.24	1.56
Houston	2.04	9.57	16.39	10.45	6.1	13.6	7.35
Istanbul	16.26	5.47	4.51	18.28	22.16	315.76	0.32
Izmir	10.36	4.56	5.45	21.91	18.34	187.52	0.53
Kiev	11.43	5.83	7.24	17.15	13.8	174.83	0.57
Lisbon	17.75	4.09	4.91	24.43	20.36	108.88	0.92
Ljubljana	13.32	3.57	3.62	27.99	27.62	83	1.2
London	14.5	3.23	4.6	30.92	21.73	92.59	1.08
Los Angeles	6.43	5.68	6.36	17.62	15.71	43.38	2.31
Luxembourg	13.52	3	3.36	33.3	29.79	79.35	1.26
Manchester	7.35	5	4.62	20.02	21.66	47.8	2.09
Melbourne	8.42	4.05	3.7	24.72	26.99	55.71	1.8
Montreal	7.93	3.82	5.15	26.16	19.43	50.06	2
Munich	16.24	2.39	2.53	41.88	39.55	93.41	1.07
New York	9.94	4.62	5.82	21.66	17.17	68.09	1.47
Nizhny Novgorod	13.78	4.96	4.12	20.18	24.26	147.26	0.68
Odessa	12.21	6.02	6.43	16.62	15.56	229.76	0.44
Ottawa	5.58	6.42	7.23	15.57	13.83	36.31	2.75
Perth	5.44	4.84	5.44	20.66	18.38	36.48	2.74
Philadelphia	3.96	6.51	15.9	15.36	6.29	27.49	3.64
Phoenix	3.77	6.68	9.77	14.97	10.24	25.84	3.87
Prague	17.65	2.55	2.75	39.25	36.38	111.5	0.9
Reykjavik	7.66	5.27	6.46	18.97	15.48	57.23	1.75
Riga	8.79	4.36	5.46	22.95	18.32	55.79	1.79
Rotterdam	6.48	6.05	6.09	16.53	16.43	38.61	2.59
Saint Helier	11.32	4.6	4.21	21.75	23.75	74.78	1.34
Saint Petersburg	17.95	4.25	4.07	23.55	24.59	188	0.53
San Diego	6.33	5.05	7.94	19.81	12.6	43.9	2.28
San Francisco	7.12	5.53	5.69	18.1	17.58	48.66	2.06
Santiago	18.59	3.85	4.41	25.96	22.67	155.73	0.64
Seoul	32.32	1.06	1.33	94.12	75.04	215.42	0.46
Stockholm	12.78	2.81	3.35	35.57	29.82	77.99	1.28
Sydney	10.39	3.6	4.16	27.74	24.04	67.3	1.49
Tallinn	9.69	4.03	4.17	24.81	23.98	61.38	1.63
Den Haag	7.2	5.71	5.52	17.52	18.1	42.45	2.36
Toronto	10.58	3.89	3.9	25.72	25.64	67.27	1.49

Vancouver	11.89	4.05	4.08	24.71	24.54	74.09	1.35
Vienna	13.96	2.75	3.18	36.35	31.46	85.82	1.17
Washington	5.45	5.83	9.95	17.16	10.05	37.54	2.66
Winnipeg	3.54	8.82	7.01	11.34	14.27	22.93	4.36
Yekaterinburg	9.51	4.17	4.67	23.97	21.4	110.56	0.9

2.1. CRITIC (Criteria Importance through Strategic Correlation) Method

The CRITIC method is one of the weighting methods that determines the objective weights of the criteria introduced in the literature by Diakoulaki et al. (1995). In this method, the standard deviation of the criteria and the correlation between the criteria are included in the process of weighting the criteria. The application process of this method consists of 5 steps and these steps are shown in Figure 4 (Diakoulaki et al., 1995).

Step 1: The X matrix is created, which shows the performance of alternatives consisting of different criteria and different options. An example matrix X is shown in equation.

$$X = \begin{bmatrix} x_{11} x_{12} & \cdots & x_{1n} \\ x_{21} x_{22} & \cdots & x_{2n} \\ \vdots \quad \vdots & \ddots & \vdots \\ x_{m1} x_{m2} & \cdots & x_{mn} \end{bmatrix}; i = 1, \ldots \ldots m \; ve \; j = 1, \ldots n$$

Step 2: The decision matrix is normalized based on whether it is focused on benefits or costs. Equation 2 is used to normalize the decision matrix based on benefits. Equation 3 is used to normalize the decision matrix based on costs.

$$r_{ij} = \frac{X_{ij} - min\, X_{ij}}{maxX_{ij} - min\, X_{ij}} \qquad r_{ij} = \frac{maxX_{ij} - X_{ij}}{maxX_{ij} - min\, X_{ij}}$$

Step 3: At this step, equation 4 is used to figure out the correlation coefficients based on the data from the normalized decision matrix.

$$\frac{\sum_{i=1}^{m} (r_{ij} - r_j) * (r_{ik} - r_k)}{\sqrt{\sum_{i=1}^{m} (x_{ij} - \bar{x}_j)^2 * \sum_{i=1}^{m} (x_{ik} - \bar{x}_k)^2}} ; j, k = 1, \ldots, n$$

Step 4: "1 -Pjk" values are obtained by subtracting the correlation coefficients from 1. The cumulative sum of this obtained value is multiplied by the standard deviation values "σj" to obtain the "Cj" value. Equation 5 is used to figure out Cj, and equation 6 is used to figure out σj.

$$c_j = \sigma_j \sum_{k=1}^{n} \left(1 - p_{jk}\right); \quad j = 1, \ldots, n \qquad \sigma_j = \sqrt{\frac{1}{n-1} \sum_{j=1}^{n} (x_{ij} - \bar{x}_j)^2}; \; i = 1, \ldots, m$$

Step 5: The "Cj" values obtained are divided by the total "Cj" values, and the Wj values for which the weights of the criteria are determined are obtained. Wj values are calculated by equation 7.

$$w_j = \frac{c_j}{\sum_{i=1}^{n} c_j}; \; j = 1, \ldots, n$$

Figure 4: The application steps of CRITIC method

2.2. Ranking of Countries Based on MCDM Methods

In the rest of this section, the steps of the methods used in the study are explained mathematically.

2.2.1. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) Method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is defined in five steps shown in Figure 5 (Erdin & Ozkaya, 2017):

Step 1. First of all, normalization is done to the decision matrix. Using the r_{ij} values calculated here, the R matrix is obtained:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}}, i = 1, \dots, m; j = 1, \dots, n$$

Step 2. By applying the weighting process stated below to the matrix in the first step, the v_{ij} matrix is obtained with the v_{ij} weighted normal values. w_j represents the weight of the J-th criterion or indicator.

$$v_{ij} = w_j r_{ij}, \sum_{j=1}^{n} w_j = 1$$

Step 3. In this step, positive ideal ($A*$) and negative ideal (A^-) solutions are determined:

$$A^* = \left\{\left(\max_i v_{ij} \middle| j \in C_b\right), \left(\min_i v_{ij} \middle| j \in C_c\right)\right\} = \{v_j^* \mid j = 1,2, \dots, m\}$$

$$A^- = \left\{\left(\min_i v_{ij} \middle| j \in C_b\right), \left(\max_i v_{ij} \middle| j \in C_c\right)\right\} = \{v_j^- \mid j = 1,2, \dots, m\}$$ When indicator j is a benefit indicator:

$$v_j^+ = max\{v_{ij}, i = 1, \dots, m\}, v_j^- = \min(v_{ij}, i = 1, \dots, m)$$ When indicator j is a cost indicator:

$$v_j^- = max\{v_{ij}, i = 1, \dots, m\}, v_j^+ = \min(v_{ij}, i = 1, \dots, m)$$

Step 4. The deviations of all alternatives from positive and negative solutions (discrimination criteria) are obtained individually using the following equations using the m-dimensional Euclidean distance:

$$S_i^* = \sqrt{\sum_{j=1}^{m} \left(v_{ij} - v_j^*\right)^2}, j = 1,2, \dots, m$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} \left(v_{ij} - v_j^-\right)^2}, j = 1,2, \dots, m$$

Step 5. In this step, the relative proximity to the ideal solution is determined. Then, sort results in descending RC_i.

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-}, i = 1, \dots, m$$

Figure 5: The application steps of TOPSIS method

2.2.2. VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Resenje) Multi-Criteria Optimization and Compromise Solution Method

The process steps of the VIKOR method are presented in Figure 6 (Ozkaya & Erdin, 2020):

Step 1. Calculating the positive ideal solution f_i^* and negative ideal solution f_i^-. I_1 is a benefit indicator, I_2 is a cost indicator.

$$f_i^* = \left[\left(\max_j f_{ij} \,\middle|\, i \in I_1\right), \left(\min_j f_{ij} \,\middle|\, i \in I_2\right)\right], \forall_i$$

$$f_i^- = \left[\left(\min_j f_{ij} \,\middle|\, i \in I_1\right), \left(\max_j f_{ij} \,\middle|\, i \in I_2\right)\right], \forall_i$$

Step 2. Calculate the ***Sj*** and ***Rj*** of the scheme. W_i represents the weight of index ***i***.

$$S_j = \sum_i^n \frac{w_i(f_i^* - f_{ij})}{(f_i^* - f_i^-)}, \forall_j$$

$$R_j = max_i\left[\frac{w_i(f_i^* - f_{ij})}{(f_i^* - f_i^-)}\right], \forall_j$$

Step 3. Calculate ***Q*** of each scheme.

$$Q_j = \frac{v(S_j - S^*)}{(S^- - S^*)} + \frac{(1-v)(R_j - R^*)}{(R^- - R^*)}, \forall_j$$

$$S^* = \min_j S_j\,;\, S^- = \max_j S_j\,;\, R^* = \min_j R_j\,;\, R^- = \max_j R_j$$

Condition 1 (C1)—(Acceptable advantage):

$Q(A_2) - Q(A_1) \geq DQ$

$DQ = 1/(m - 1)$ (m is the number of alternatives)

Condition 2 (C2)—(Acceptable stability):

In order to ensure the stability condition for the compromised solution found; A1 alternative with the highest Q value must have received the highest value from at least one of the S and R values.

Step 4. Only after these conditions are met, the alternative with the smallest Q value can be considered as the best option.

Figure 6: The application steps of VIKOR method

2.2.3. PROMETHEE (Preference ranking organization method for enrichment evaluation)

PROMETHEE method consists of 4 steps shown in Figure 7 (Brans & Vincke, 1985; Dağdeviren & Erarslan, 2008; Ishizaka & Nemery, 2011):

Step 1. Evaluate the n solutions (a1, a2, ..., an) in A under m criteria C_k, and get the decision matrix X = (x_{ik}) (i = 1, 2, ..., n; k = 1, 2, ..., m). When $G_k(d_{ij}) = 0$, there is no difference between scheme ai and scheme aj. When $G_k(d_{ij}) = 1$, scheme a_i has definite priority over scheme aj.

$$G_k(d_{ij}) = P_k(a_i, a_j)$$

Step 2. Based on the weight (W) provided by the decision maker, a multi-criteria preference ranking index (H) is calculated.

$$H(a_i, a_j) = \sum_{k=1}^{m} W_k P_k(a_i, a_j)$$

Step 3. The positive and negative directions of the order of A_i's preference are defined by Φ^+(ai) and Φ^-(ai), respectively.

$$\Phi^+(a_i) = \sum_{j=1}^{n} H(a_i, a_j) \text{ and } \Phi^-(a_i) = \sum_{j=1}^{n} H(a_j, a_i)$$

$$\Phi(a_i) = \Phi^+(a_i) - \Phi^-(a_i)$$

Step 4. The exact ranking of the alternatives is obtained according to the values of $\Phi(a_i)$

Figure 7: The application steps of PROMETHEE method

2.2.4. SAW (Simple Additive Weighting) Method

The application steps in the SAW approach are shown in Figure 8 (Ömürbek, Karaatlı, et al., 2016; Ömürbek, Karaatli, et al., 2016; Yeh, 2002):

Step 1. Normalizing decision matrix values

Normalization process differs depending on whether the criteria are benefit (maximization) or cost (minimization)

criteria: $$r_{ij} = \begin{cases} \frac{x_{ij}}{\max X_{ij}} & i = 1, \dots, ; j = 1, \dots, n \text{ for benefit criteria} \\ \frac{minX_{ij}}{x_{ij}} & i = 1, \dots, m; j = 1, \dots, n \text{ for costcriteria} \end{cases}$$

Step 2. Determination of preference values for each alternative

$S_j = \sum_{j=1}^{m} w_j r_{ij}$ $\quad i = 1, \dots, m$ $\quad w_{ij}$: Weight of the relevant criterion

Step 3. The relative value (S_j%) of each alternative is obtained. The large value indicates that the relevant alternative should be preferred more.

$$S_j^{\%} = \frac{S_j}{\sum_{j=1}^{n} S_j}$$

Figure 8: The application steps of SAW method

2.2.5. ELECTRE (Elimination and Choice Translating Reality English) Method

The ELECTRE (Elimination and Choice Translating Reality English) technique utilizes a procedure that can be broken down into eight distinct steps, as seen in Figure 9 (Triantaphyllou, 2000):

Step 1. This process converts the elements of the decision matrix into dimensionless comparable elements by applying Equation

$$x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} xa_{kj}^2}}$$

Thus, the normalized matrix X is shown as

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}$$

where m presents the number of alternatives, n shows the number of criteria, and x_{ij} is the normalized preference measure of the i-th alternative with regard to the j-th criterion.

Step 2. Construction of weighted standard decision matrix (Y):

$$\sum_{i=1}^{n} w_i = 1$$

Then the elements in each column of the *X* matrix are multiplied by the corresponding w_i value to form the *Y* matrix :

$$Y_{ij} = \begin{bmatrix} w_1 x_{11} & \cdots & w_n x_{1n} \\ \vdots & \ddots & \vdots \\ w_1 x_{m1} & \cdots & w_n x_{mn} \end{bmatrix}$$

Step 3. Determining the set of concordance (C_{kl}) and discordance (D_{kl}). The Y matrix is used to determine the fit sets.

$$C_{kl} = \{j | y_{kj} \geq y_{lj}\}$$

Step 4. Concordance sets are used to create the concordance matrix (*C*). The matrix *C* is a mxm matrix and does not have a value for k = l.

$$C_{kl} = \sum_{j \in C_{kl}} w_j \; for \; j = 1, 2, 3, \ldots, n.$$

The discordance matrix (D) shows the degree that a particular alternative A_k is worse than a competing alternative A_l. The elements of the discordance matrix (D) are calculated by Equation:

$$d_{kl} = \frac{\max_{j \in D_{kl}} |y_{kj} - y_{lj}|}{\max_{j} |y_{kj} - y_{lj}|}$$

Step 5. The concordance threshold value (c) is obtained by the formula $c = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} c_{kl}$

m shows the number of decision points in the formula. More specifically, the value of c is equal to the product of the total value of the elements of C matrix and $\frac{1}{m(m-1)}$.

Based on the threshold value, the elements of the concordance dominance matrix F are decided by

$$c_{kl} \geq c \Rightarrow f_{kl} = 1, c_{kl} < c \Rightarrow f_{kl} = 0$$

it also shows the same decision points on the diagonal of the matrix, so it has no value. In a similar way, the discordance dominance matrix G is described by using a threshold value d,

$$d = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} d_{kl} \qquad d_{kl} \geq d \Rightarrow g_{kl} = 1, d_{kl} < d \Rightarrow g_{kl} = 0$$

Step 6. Construction of the aggregate dominance matrix (E). Here, the E is a mxm matrix depending on the C and D matrices and it consists of 1 or 0 values.

$$e_{kl} = f_{kl} \times g_{kl}$$

Step 7. Determining the order of importance for decision points. The rows and columns of the E matrix represent the decision points. For example, if the matrix E is calculated as

$$E = \begin{bmatrix} - & 0 & 0 \\ 1 & - & 0 \\ 1 & 1 & - \end{bmatrix}$$

$$e_{21} = 1, e_{31} = 1, and \; e_{32} = 1$$

In this case, if the decision points are expressed with the symbol A_i (i = *1, 2, . . . ,m*) the order of importance for the decision points will be in the form of A_3, A_2, and A_1.

Figure 9: The application steps of ELECTRE method

2.2.6. COPRAS (Complex Proportional Assesment) Method

COPRAS (Complex Proportional Assessment) is an MCDM method used to evaluate and rank the alternatives (Özdağoğlu, 2013). The evaluation steps of the approach are briefly listed in Figure 10 (Chatterjee et al., 2011; Das et al., 2012; Kaklauskas et al., 2010):

Variables used in the COPRAS method; Ai: *i*-th alternative I = 1, 2,…., m; C_j: j-th criterion j= 1, 2, …., n; w_j: significance weight of the *j*-th criterion *j* = 1, 2, …, n; x_{ij}: j-th level of evaluation criterion *j* = 1, 2, …, n.

Step 1. The decision matrix formed by the x_{ij} values is obtained.

$$D = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ . \\ A_m \end{matrix} \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdot & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdot & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdot & x_{3n} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ x_{m1} & x_{m2} & x_{m3} & \cdot & x_{mn} \end{bmatrix}$$

Step 2. Normalized values are obtained.

$$X_{ij}^{*} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \forall_j = 1, 2, \dots, n$$

Step 3. The weighted normalized decision matrix D 'consisting of d_{ij} is obtained.

$$D' = d_{ij} = x_{ij}^{*} \times w_j$$

Step 4. The sum of the weighted normalized decision matrix values of the benefit and cost criteria is calculated using Equations.

$$S_{i+} = \sum_{j=1}^{k} d_{ij}, j = 1, 2, \dots, k$$

$$S_{i-} = \sum_{j=k+1}^{n} d_{ij}, j = k+1, k+2, \dots, n$$

Step 5. In this step, the relative importance value (Q_i) of each alternative is calculated.

$$Q_i = S_{i+} + \frac{\sum_{i=1}^{m} S_{i-}}{S_{i-} \times \sum_{i=1}^{m} \frac{1}{S_{i-}}}$$

Step 6. The highest relative priority value is determined.

$$Q_{max} = max\{Q_i\}, \forall_i = 1, 2, \dots, n$$

Step 7. The performance index (P_i) value of each alternative is obtained.

$$P_i = \frac{Q_i}{Q_{max}} \times \%100$$

Performance index value (P_i) which is equal to 100 is determined as the best alternative in terms of alternative evaluation criteria. The COPRAS ranking table is obtained by ranking the performance index value of each alternative in descending order.

Figure 10: The application steps of COPRAS method

2.2.7. ARAS (A New Additive Ratio Assessment) Method

The process of the ARAS method consists of 4 steps presented in Figure 11 (2010).

The first three steps of the method are the same as the COPRAS method. In the last step of the ARAS method, the optimality function value of each alternative is calculated, and thus it is possible to evaluate the alternatives.

Si represents the optimality function value of the *i*-th alternative. It is equal to the sum of all criterion values for each alternative.

$$S_i = \sum_{j=1}^{n} \hat{x}_{ij}, i = 0, 1, \dots, m$$

The alternative with the largest S_i value is defined as the most efficient alternative. Also in this step, K_i utility degrees are obtained by dividing each S_i value by S_0 optimal function value.

$$K_i = \frac{S_i}{S_0}, i = 0, 1, \dots, m$$

The relative efficiency of the utility function values (K_i) of each alternative is determined with K_i, which takes values in the range of [0,1]. An ARAS ranking table from the best alternative to the worst ranked alternative in terms of criteria is obtained by ordering the Ki values in descending order.

Figure 11: The application steps of ARAS method

2.2.8. MAUT (Multi-attribute Utility Theory) Method

Figure 12 displays the two stages that comprise the operational procedure of the MAUT method (Konuşkan et al., 2014).

Step 1. In the first step, the decision matrix elements are normalized. In the normalization process, the values of each criterion are first converted so that the best value is one (1) and the worst value is zero (0).

$$u_i(x_i) = \frac{x - x_i^-}{x_i^+ - x_i^-}$$

Definitions of variables in this formula are shown below:

x_i^+:The largest value of the relevant criterion.

x_i^- The smallest value of the relevant criterion.

x:Current value of the cell under calculation.

Step 2. The utility values of each alternative are calculated:

$$U(x) = \sum_{1}^{m} (u_i(x_i) \times w_i)$$

U(*x*): Benefit value of the relevant alternative.

$u_i(x_i)$: The utility value of the alternative in terms of the relevant criteria.

wi: weight value of the relevant criterion.

Step 3. The large value *U*(*x*) indicates that the relevant alternative should be preferred more.

Figure 12: The application steps of MAUT method

2.3. Borda Count Method

The Borda Count Method is a reduction and data merging technique that aims to create a final ranking by considering the rankings of alternatives in different preference lists (Lamboray, 2007; Nuray & Can, 2006). In the method, zero points are assigned for the alternatives in the last row of the preference lists with n alternatives, and (n-1) points are assigned for the alternatives in the top row. In calculating the Borda score of each alternative, the score assigned to the rank of the alternative in each list is multiplied by the weight of the relevant list, and finally the calculated values of the relevant alternative in each list are added. The alternatives are ranked from high to low to obtain the final reduced composite ranking table (Lippman, 2017).

2.4. K-means Clustering Algorithm

The steps of K-means algorithm are shown in Figure 13 (Yi et al., 2010):

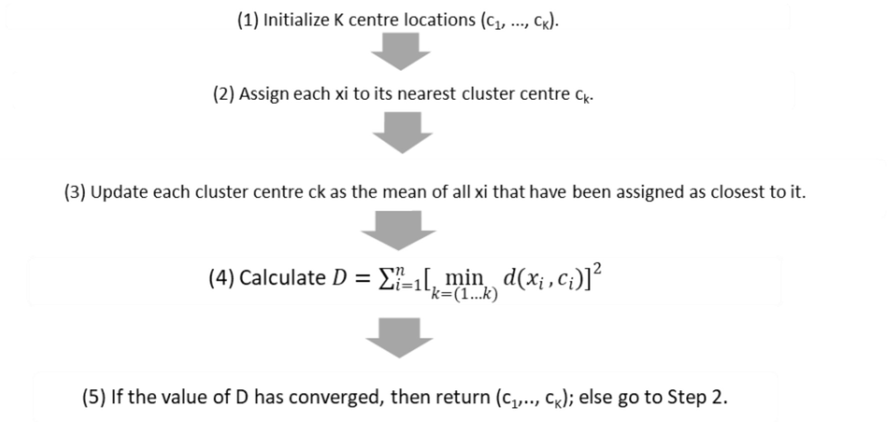

Figure 13: The application steps of K-means clustering method

3. Results

Figure 14 illustrates the weights of the criteria for the Property Prices Index that were derived using the Critic technique (percent).

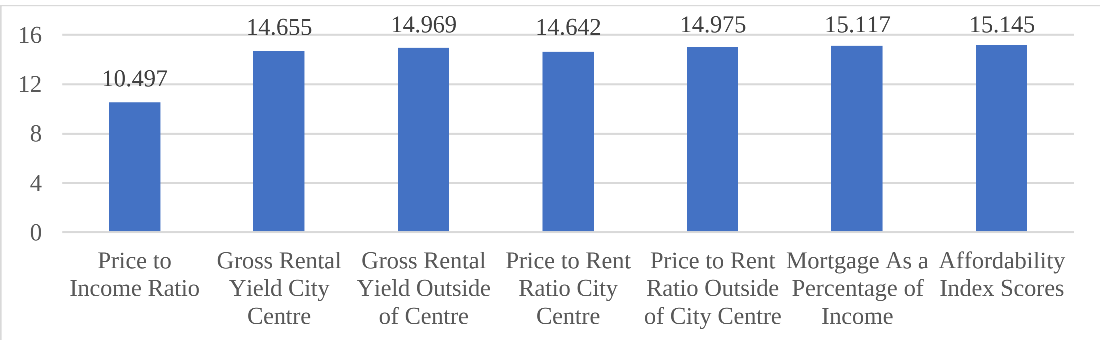

Figure 14: Critic method weights of the criteria of the Property Prices Index (%).

Using the Critic approach weighting, it can be observed that authorities and politicians in cities where residents are unable to afford to purchase property should take action immediately. Because the worst-performing cities in the study had low values on these metrics.

Relative values (Sj%) are computed for each city in the SAW study. In terms of Property Index criteria, the best city is the one with the highest value. Table 4 displays the relative values and ranks. Houston is the greatest city, while Dallas, Philadelphia, Chicago, and Winnipeg round out the top five. On the other side, Seoul, Munich, Prague, Vienna, and Budapest are the five worst-performing cities.

Table 4. Relative Preference Values (Sj%) and Ranking of Cities According to SAW Analysis.

Cities, Countries	Sj%	Cities, Countries	Sj%
Houston, TX, United States	0.069546	Antalya, Turkey	0.23832
Dallas, TX, United States	0.066723	Saint Helier, Jersey	0.22815
Philadelphia, PA, United	0.046692	Melbourne, Australia	0.22701
Chicago, IL, United States	0.044671	Tallinn, Estonia	0.22496
Winnipeg, Canada	0.042117	Izmir, Turkey	0.21879
Edmonton, Canada	0.039839	Istanbul, Turkey	0.21215
Calgary, Canada	0.039535	Yekaterinburg, Russia	0.20861
Phoenix, AZ, United States	0.039348	Vancouver, Canada	0.20731
Adelaide, Australia	0.033908	Toronto, Canada	0.20698
Christchurch, New Zealand	0.033419	Nizhny Novgorod,	0.20596
Washington, DC, United	0.032652	Berlin, Germany	0.20544
Ottawa, Canada	0.030376	Sydney, Australia	0.20330
Rotterdam, Netherlands	0.027021	Lisbon, Portugal	0.20039
Dublin, Ireland	0.026798	Gothenburg, Sweden	0.19209
San Diego, CA, United States	0.026455	Ankara, Turkey	0.18631
Los Angeles, CA, United	0.025716	Auckland, New Zealand	0.18544
Den Haag, Netherlands	0.024487	Cologne, Germany	0.18481
Perth, Australia	0.024284	London, United	0.17636
San Francisco	0.023417	Ljubljana, Slovenia	0.17445
Reykjavik, Iceland	0.022815	Saint Petersburg, Russia	0.17183
Brisbane, Australia	0.021992	Santiago, Chile	0.17015
Birmingham, UK	0.021344	Bratislava, Slovakia	0.16805
Kiev (Kyiv), Ukraine	0.020906	Hamburg, Germany	0.16310
Manchester, United Kingdom	0.020729	Luxembourg,	0.15312
Boston, MA, United States	0.020679	Stockholm, Sweden	0.14873
Odessa (Odesa), Ukraine	0.019689	Budapest, Hungary	0.14228
Riga, Latvia	0.019180	Vienna, Austria	0.13697
New York, NY, United States	0.019089	Prague, Czech Republic	0.10693
Montreal, Canada	0.018349	Munich, Germany	0.10592

Amsterdam, Netherlands	0.016966	Seoul, South Korea	0.00619

Table 5 displays the TOPSIS ranking of cities according to the Property Price Index. The city with the highest Ci* value is the best city based on Property Index criteria, as determined by the ranking generated from the TOPSIS study. While Houston is the greatest city in the rating, Dallas, Philadelphia, Chicago, and Winnipeg round out the top five. On the other side, the five cities with the lowest performance are Seoul, Munich, Prague, Vienna, and Stockholm.

Table 5. TOPSIS ranking of cities in terms of Property Price Index.

Rank	Cities, Countries	Ci*	Rank	Cities, Countries	Ci*
1	Houston, TX, United States	0.96516	31	Montreal, Canada	0.26127
2	Dallas, TX, United States	0.92806	32	Izmir, Turkey	0.24866
3	Philadelphia, PA, United States	0.63751	33	Amsterdam, Netherlands	0.24763
4	Chicago, IL, United States	0.62913	34	Saint Helier, Jersey	0.2457
5	Winnipeg, Canada	0.58205	35	Nizhny Novgorod, Russia	0.24223
6	Edmonton, Canada	0.56122	36	Melbourne, Australia	0.23451
7	Calgary, Canada	0.55567	37	Tallinn, Estonia	0.23283
8	Phoenix, AZ, United States	0.55541	38	Yekaterinburg, Russia	0.22574
9	Adelaide, Australia	0.47897	39	Lisbon, Portugal	0.22273
10	Christchurch, New Zealand	0.47375	40	Vancouver, Canada	0.21982
11	Washington, DC, United States	0.46548	41	Ankara, Turkey	0.2172
12	Ottawa, Canada	0.43356	42	Toronto, Canada	0.21601
13	Dublin, Ireland	0.39145	43	Berlin, Germany	0.20947
14	Rotterdam, Netherlands	0.38894	44	Sydney, Australia	0.2091
15	San Diego, CA, United States	0.3787	45	Saint Petersburg, Russia	0.20618
16	Los Angeles, CA, United States	0.3696	46	Santiago, Chile	0.19666
17	Den Haag, Netherlands	0.35496	47	Gothenburg, Sweden	0.19478
18	Perth, Australia	0.34449	48	Auckland, New Zealand	0.1945
19	San Francisco, CA, United States	0.33984	49	Cologne, Germany	0.18937
20	Reykjavik, Iceland	0.33246	50	London, United Kingdom	0.18672
21	Kiev (Kyiv), Ukraine	0.331	51	Ljubljana, Slovenia	0.18556
22	Odessa (Odesa), Ukraine	0.31985	52	Bratislava, Slovakia	0.17809
23	Brisbane, Australia	0.31379	53	Hamburg, Germany	0.16578
24	Birmingham, United Kingdom	0.30773	54	Luxembourg, Luxembourg	0.15864
25	Manchester, United Kingdom	0.30134	55	Budapest, Hungary	0.15297
26	Boston, MA, United States	0.30012	56	Stockholm, Sweden	0.15214
27	New York, NY, United States	0.28197	57	Vienna, Austria	0.14123
28	Riga, Latvia	0.27747	58	Prague, Czech Republic	0.11356
29	Antalya, Turkey	0.2696	59	Munich, Germany	0.11018
30	Istanbul, Turkey	0.2635	60	Seoul, South Korea	0.01145

Table 6 displays the ranks derived according to each Qi value obtained from the VIKOR analysis. In the VIKOR study, city rankings were determined by ascendingly ordering the Qi values generated for each city.

Table 6. Ranking of cities according to the VIKOR analysis.

Rank	Cities, Countries	Qi Score	Rank	Cities, Countries	Qi Score
1	Houston, TX, United States	0.000000	31	Antalya, Turkey	0.761852
2	Dallas, TX, United States	0.040849	32	Saint Helier, Jersey	0.772290
3	Philadelphia, PA, United States	0.330705	33	Melbourne, Australia	0.773460
4	Chicago, IL, United States	0.359957	34	Tallinn, Estonia	0.775558
5	Winnipeg, Canada	0.396904	35	Izmir, Turkey	0.781893
6	Edmonton, Canada	0.429865	36	Istanbul, Turkey	0.788700
7	Calgary, Canada	0.434267	37	Yekaterinburg, Russia	0.792335
8	Phoenix, AZ, United States	0.436973	38	Vancouver, Canada	0.793673
9	Adelaide, Australia	0.515687	39	Toronto, Canada	0.794006
10	Christchurch, New Zealand	0.522772	40	Nizhny Novgorod, Russia	0.795050
11	Washington, DC, United States	0.533868	41	Berlin, Germany	0.795583
12	Ottawa, Canada	0.566800	42	Sydney, Australia	0.797780
13	Rotterdam, Netherlands	0.615354	43	Lisbon, Portugal	0.800769
14	Dublin, Ireland	0.618572	44	Gothenburg, Sweden	0.809286
15	San Diego, CA, United States	0.623545	45	Ankara, Turkey	0.815215
16	Los Angeles, CA, United States	0.634229	46	Auckland, New Zealand	0.816107
17	Den Haag, Netherlands	0.652020	47	Cologne, Germany	0.816753
18	Perth, Australia	0.654954	48	London, United Kingdom	0.825419
19	San Francisco, CA, United States	0.667503	49	Ljubljana, Slovenia	0.827382
20	Reykjavik, Iceland	0.676213	50	Saint Petersburg, Russia	0.830070
21	Brisbane, Australia	0.688124	51	Santiago, Chile	0.831794
22	Birmingham, United Kingdom	0.697499	52	Bratislava, Slovakia	0.833945
23	Kiev (Kyiv), Ukraine	0.703834	53	Hamburg, Germany	0.839026
24	Manchester, United Kingdom	0.706398	54	Luxembourg, Luxembourg	0.849257
25	Boston, MA, United States	0.707113	55	Stockholm, Sweden	0.853765
26	Odessa (Odesa), Ukraine	0.721443	56	Budapest, Hungary	0.860384
27	Riga, Latvia	0.728806	57	Vienna, Austria	0.865829
28	New York, NY, United States	0.730122	58	Prague, Czech Republic	0.896652
29	Montreal, Canada	0.740838	59	Munich, Germany	0.897688
30	Amsterdam, Netherlands	0.760840	60	Seoul, South Korea	1.000000

In accordance with the ARAS approach, the priority values (Si) and benefit values (Ki) of all cities were determined and are shown in Table 7. When the percentage value (percent Ki) of the utility value is sorted in decreasing order, a table reflecting the ranking from best to worst city according to Property Price Index criteria is generated. Table 7 ranks the top five cities in terms of Property Price Index as Houston, Dallas, Philadelphia, Chicago, and Winnipeg, in that order. Vienna, Budapest, Munich, Prague, and Seoul are the five cities with the lowest ratings.

Table 7. ARAS optimality function values and city rankings.

Optimal Value	**0.05773**			**ARAS Method Ranking (% Ki)**	
City, Country	**Si**	**Ki**	**%Ki**		
Adelaide, Australia	0.02691	0.46611	46.61	Houston, TX, United States	98.67
Amsterdam, Netherlands	0.01297	0.22467	22.47	Dallas, TX, United States	93.51
Ankara, Turkey	0.00911	0.15783	15.78	Philadelphia, PA, United	64.26
Antalya, Turkey	0.01177	0.20393	20.39	Chicago, IL, United States	61.40
Auckland, New Zealand	0.00990	0.17153	17.15	Winnipeg, Canada	57.08
Berlin, Germany	0.01154	0.19998	20.00	Edmonton, Canada	55.93
Birmingham, United Kingdom	0.01643	0.28468	28.47	Calgary, Canada	54.75
Boston, MA, United States	0.01577	0.27317	27.32	Phoenix, AZ, United States	54.47
Bratislava, Slovakia	0.00895	0.15510	15.51	Adelaide, Australia	46.61
Brisbane, Australia	0.01729	0.29954	29.95	Christchurch, New Zealand	45.40
Budapest, Hungary	0.00745	0.12904	12.90	Washington, DC, United States	44.13
Calgary, Canada	0.03161	0.54746	54.75	Ottawa, Canada	40.59
Chicago, IL, United States	0.03545	0.61402	61.40	Rotterdam, Netherlands	35.98
Christchurch, New Zealand	0.02621	0.45398	45.40	San Diego, CA, United States	35.74
Cologne, Germany	0.01030	0.17844	17.84	Dublin, Ireland	34.62
Dallas, TX, United States	0.05399	0.93514	93.51	Los Angeles, CA, United	34.21
Dublin, Ireland	0.01998	0.34616	34.62	Perth, Australia	33.67
Edmonton, Canada	0.03229	0.55933	55.93	Den Haag, Netherlands	32.45
Gothenburg, Sweden	0.01094	0.18949	18.95	San Francisco, United States	30.81
Hamburg, Germany	0.00928	0.16077	16.08	Brisbane, Australia	29.95
Houston, TX, United States	0.05696	0.98669	98.67	Reykjavik, Iceland	29.79
Istanbul, Turkey	0.00976	0.16906	16.91	Birmingham, United Kingdom	28.47
Izmir, Turkey	0.01086	0.18811	18.81	Manchester, United Kingdom	27.62
Kiev (Kyiv), Ukraine	0.01446	0.25055	25.05	Boston, MA, United States	27.32
Lisbon, Portugal	0.01017	0.17616	17.62	Riga, Latvia	25.56
Ljubljana, Slovenia	0.00924	0.16012	16.01	Montreal, Canada	25.21
London, United Kingdom	0.00941	0.16306	16.31	Kiev (Kyiv), Ukraine	25.05
Los Angeles, CA, United States	0.01975	0.34208	34.21	New York, NY, United States	24.75
Luxembourg, Luxembourg	0.00837	0.14502	14.50	Odessa (Odesa), Ukraine	23.04
Manchester, United Kingdom	0.01594	0.27616	27.62	Amsterdam, Netherlands	22.47
Melbourne, Australia	0.01251	0.21663	21.66	Melbourne, Australia	21.66
Montreal, Canada	0.01455	0.25211	25.21	Tallinn, Estonia	21.18
Munich, Germany	0.00587	0.10165	10.17	Saint Helier, Jersey	20.56
New York, NY, United States	0.01429	0.24750	24.75	Antalya, Turkey	20.39
Nizhny Novgorod, Russia	0.00995	0.17242	17.24	Berlin, Germany	20.00
Odessa (Odesa), Ukraine	0.01330	0.23043	23.04	Toronto, Canada	19.34

Ottawa, Canada	0.02343	0.40591	40.59	Sydney, Australia	19.25
Perth, Australia	0.01944	0.33669	33.67	Vancouver, Canada	19.01
Philadelphia, PA, United States	0.03710	0.64264	64.26	Gothenburg, Sweden	18.95
Phoenix, AZ, United States	0.03144	0.54466	54.47	Izmir, Turkey	18.81
Prague, Czech Republic	0.00571	0.09893	9.89	Yekaterinburg, Russia	18.65
Reykjavik, Iceland	0.01720	0.29790	29.79	Cologne, Germany	17.84
Riga, Latvia	0.01476	0.25558	25.56	Lisbon, Portugal	17.62
Rotterdam, Netherlands	0.02077	0.35984	35.98	Nizhny Novgorod, Russia	17.24
Saint Helier, Jersey	0.01187	0.20563	20.56	Auckland, New Zealand	17.15
Saint Petersburg, Russia	0.00824	0.14269	14.27	Istanbul, Turkey	16.91
San Diego, CA, United States	0.02063	0.35738	35.74	London, United Kingdom	16.31
San Francisco, United States	0.01779	0.30813	30.81	Hamburg, Germany	16.08
Santiago, Chile	0.00841	0.14563	14.56	Ljubljana, Slovenia	16.01
Seoul, South Korea	0.00044	0.00764	0.76	Ankara, Turkey	15.78
Stockholm, Sweden	0.00825	0.14295	14.29	Bratislava, Slovakia	15.51
Sydney, Australia	0.01111	0.19246	19.25	Santiago, Chile	14.56
Tallinn, Estonia	0.01223	0.21181	21.18	Luxembourg, Luxembourg	14.50
Den Haag, Netherlands	0.01874	0.32452	32.45	Stockholm, Sweden	14.29
Toronto, Canada	0.01117	0.19343	19.34	Saint Petersburg, Russia	14.27
Vancouver, Canada	0.01097	0.19007	19.01	Vienna, Austria	13.03
Vienna, Austria	0.00753	0.13035	13.03	Budapest, Hungary	12.90
Washington, DC, United States	0.02547	0.44126	44.13	Munich, Germany	10.17
Winnipeg, Canada	0.03295	0.57083	57.08	Prague, Czech Republic	9.89
Yekaterinburg, Russia	0.01077	0.18651	18.65	Seoul, South Korea	0.76

Table 8 presents the ranking of cities according to the computed COPRAS benefit degrees. According to the research, Houston is rated the best city in terms of benefits. The remaining four cities in the top five are Dallas, Philadelphia, Chicago, and Winnipeg, in that order. Vienna, Budapest, Munich, Prague, and Seoul have the lowest performance scores out of the five cities.

Table 8. Result matrix of the COPRAS method.

City, Country	Sj+	Sj-	Rank	City, Country	Qj	Nj
Adelaide, Australia	0.026909	0	1	Houston, TX, United States	0.056963	100
Amsterdam, Netherlands	0.012971	0	2	Dallas, TX, United States	0.053987	94.78
Ankara, Turkey	0.009112	0	3	Philadelphia, United States	0.037101	65.13
Antalya, Turkey	0.011773	0	4	Chicago, IL, United States	0.035448	62.23
Auckland, New Zealand	0.009902	0	5	Winnipeg, Canada	0.032955	57.85
Berlin, Germany	0.011545	0	6	Edmonton, Canada	0.032291	56.69
Birmingham, UK	0.016435	0	7	Calgary, Canada	0.031606	55.48
Boston, MA, United States	0.015770	0	8	Phoenix, AZ, United States	0.031444	55.20
Bratislava, Slovakia	0.008954	0	9	Adelaide, Australia	0.026909	47.24
Brisbane, Australia	0.017293	0	10	Christchurch, New Zealand	0.026209	46.01
Budapest, Hungary	0.007450	0	11	Washington, United States	0.025475	44.72

Calgary, Canada	0.031606	0	12	Ottawa, Canada	0.023434	41.14
Chicago, IL, United States	0.035448	0	13	Rotterdam, Netherlands	0.020774	36.47
Christchurch, New Zealand	0.026209	0	14	San Diego, CA, United	0.020632	36.22
Cologne, Germany	0.010302	0	15	Dublin, Ireland	0.019984	35.08
Dallas, TX, United States	0.053987	0	16	Los Angeles, United States	0.019749	34.67
Dublin, Ireland	0.019984	0	17	Perth, Australia	0.019438	34.12
Edmonton, Canada	0.032291	0	18	Den Haag, Netherlands	0.018735	32.89
Gothenburg, Sweden	0.010940	0	19	San Francisco, United	0.017789	31.23
Hamburg, Germany	0.009282	0	20	Brisbane, Australia	0.017293	30.36
Houston, TX, United States	0.056963	0	21	Reykjavik, Iceland	0.017198	30.19
Istanbul, Turkey	0.009760	0	22	Birmingham, United	0.016435	28.85
Izmir, Turkey	0.010860	0	23	Manchester, United	0.015943	27.99
Kiev (Kyiv), Ukraine	0.014464	0	24	Boston, MA, United States	0.015770	27.69
Lisbon, Portugal	0.010170	0	25	Riga, Latvia	0.014755	25.90
Ljubljana, Slovenia	0.009244	0	26	Montreal, Canada	0.014555	25.55
London, United Kingdom	0.009414	0	27	Kiev (Kyiv), Ukraine	0.014464	25.39
Los Angeles, United States	0.019749	0	28	New York, NY, United	0.014289	25.08
Luxembourg, Luxembourg	0.008372	0	29	Odessa (Odesa), Ukraine	0.013303	23.35
Manchester, UK	0.015943	0	30	Amsterdam, Netherlands	0.012971	22.77
Melbourne, Australia	0.012506	0	31	Melbourne, Australia	0.012506	21.95
Montreal, Canada	0.014555	0	32	Tallinn, Estonia	0.012228	21.47
Munich, Germany	0.005869	0	33	Saint Helier, Jersey	0.011871	20.84
New York, NY, United	0.014289	0	34	Antalya, Turkey	0.011773	20.67
Nizhny Novgorod, Russia	0.009954	0	35	Berlin, Germany	0.011545	20.27
Odessa (Odesa), Ukraine	0.013303	0	36	Toronto, Canada	0.011167	19.60
Ottawa, Canada	0.023434	0	37	Sydney, Australia	0.011111	19.51
Perth, Australia	0.019438	0	38	Vancouver, Canada	0.010973	19.26
Philadelphia, United States	0.037101	0	39	Gothenburg, Sweden	0.010940	19.20
Phoenix, AZ, United States	0.031444	0	40	Izmir, Turkey	0.010860	19.06
Prague, Czech Republic	0.005712	0	41	Yekaterinburg, Russia	0.010768	18.90
Reykjavik, Iceland	0.017198	0	42	Cologne, Germany	0.010302	18.08
Riga, Latvia	0.014755	0	43	Lisbon, Portugal	0.010170	17.85
Rotterdam, Netherlands	0.020774	0	44	Nizhny Novgorod, Russia	0.009954	17.47
Saint Helier, Jersey	0.011871	0	45	Auckland, New Zealand	0.009902	17.38
Saint Petersburg, Russia	0.008238	0	46	Istanbul, Turkey	0.009760	17.13
San Diego, CA, United	0.020632	0	47	London, United Kingdom	0.009414	16.53
San Francisco, United	0.017789	0	48	Hamburg, Germany	0.009282	16.29
Santiago, Chile	0.008407	0	49	Ljubljana, Slovenia	0.009244	16.23
Seoul, South Korea	0.000441	0	50	Ankara, Turkey	0.009112	16.00
Stockholm, Sweden	0.008253	0	51	Bratislava, Slovakia	0.008954	15.72
Sydney, Australia	0.011111	0	52	Santiago, Chile	0.008407	14.76
Tallinn, Estonia	0.012228	0	53	Luxembourg, Luxembourg	0.008372	14.70
Den Haag, Netherlands	0.018735	0	54	Stockholm, Sweden	0.008253	14.49
Toronto, Canada	0.011167	0	55	Saint Petersburg, Russia	0.008238	14.46
Vancouver, Canada	0.010973	0	56	Vienna, Austria	0.007525	13.21
Vienna, Austria	0.007525	0	57	Budapest, Hungary	0.007450	13.08

Washington, United States	0.025475	0	58	Munich, Germany	0.005869	10.30
Winnipeg, Canada	0.032955	0	59	Prague, Czech Republic	0.005712	10.03
Yekaterinburg, Russia	0.010768	0	60	Seoul, South Korea	0.000441	0.77

A partial assessment of cities based on Property Price Index criteria is generated using the PROMETHEE I approach. When the Visual PROMETHEE program's PROMETHEE I analytic findings are analyzed, it can be shown that Houston is more dominating than other cities. This city is followed in prominence by Dallas and Chicago, respectively. In order to come up with the ultimate and thorough rating, PROMETHEE II is used.

Table 9 displays the net superiority value (Phi) generated using negative (Phi) and positive (Phi+) superiority values derived from the PROMETHEE II approach received from the software. These PROMETHEE II findings illustrate positive advantage value, negative advantage value, net superiority value, and city rankings. According to this research, Houston has the greatest net Phi value among other cities according to the parameters for the property price index. Following Houston in the top five are Dallas, Chicago, Edmonton, and Philadelphia. Table 11 displays the overall performance scores of the cities according to the PROMETHEE II study.

Table 9. Positive, negative, net superiority values and complete rankings of cities obtained via PROMETHEE II analysis.

Rank	City	Phi	Phi+	Phi-	Rank	City	Phi+	Phi-
1	Houston	0,9901	0,9950	0,0050	31	Antalya	0,4368	0,5632
2	Dallas	0,9659	0,9829	0,0171	32	Melbourne	0,4028	0,5922
3	Chicago	0,8742	0,9371	0,0629	33	Saint Helier	0,3972	0,6028
4	Edmonton	0,8517	0,9258	0,0742	34	Tallinn	0,3962	0,6038
5	Philadelphia	0,8236	0,9118	0,0882	35	Izmir	0,3774	0,6201
6	Phoenix	0,8068	0,9034	0,0966	36	Yekaterinburg	0,3712	0,6238
7	Calgary	0,7999	0,9000	0,1000	37	Berlin	0,3500	0,6449
8	Winnipeg	0,7966	0,8983	0,1017	38	Sydney	0,3401	0,6574
9	Christchurch	0,7154	0,8577	0,1423	39	Vancouver	0,3312	0,6663
10	Adelaide	0,6884	0,8442	0,1558	40	Toronto	0,3304	0,6671
11	Washington	0,6507	0,8241	0,1734	41	Istanbul	0,3293	0,6707
12	Ottawa	0,6433	0,8217	0,1783	42	Lisbon	0,3284	0,6716
13	Rotterdam	0,5178	0,7589	0,2411	43	Nizhny Novgorod	0,3258	0,6742
14	Dublin	0,4822	0,7411	0,2589	44	Gothenburg	0,3065	0,6935
15	San Diego	0,4695	0,7348	0,2652	45	Ankara	0,2917	0,7083

16	Los Angeles	0,4514	0,7257	0,2743	46	Cologne	0,2733	0,7267
17	Den Haag	0,4000	0,7000	0,3000	47	Auckland	0,2716	0,7259
18	San Francisco	0,3425	0,6713	0,3287	48	London	0,2645	0,7355
19	Perth	0,3394	0,6697	0,3303	49	Santiago	0,2440	0,7560
20	Reykjavik	0,2907	0,6454	0,3546	50	Ljubljana	0,2382	0,7592
21	Birmingham	0,2389	0,6195	0,3805	51	Saint Petersburg	0,2243	0,7731
22	Brisbane	0,2337	0,6168	0,3832	52	Hamburg	0,2210	0,7790
23	Boston	0,1945	0,5934	0,3989	53	Bratislava	0,2171	0,7829
24	Manchester	0,1844	0,5922	0,4078	54	Luxembourg	0,1842	0,8158
25	Riga	0,0896	0,5422	0,4526	55	Stockholm	0,1779	0,8221
26	Kiev	0,0471	0,5223	0,4752	56	Budapest	0,1391	0,8609
27	New York	0,0361	0,5180	0,4820	57	Vienna	0,1300	0,8700
28	Montreal	-0,005	0,4976	0,5024	58	Munich	0,0925	0,9075
29	Odessa	-0,033	0,4834	0,5166	59	Prague	0,0836	0,9138
30	Amsterdam	-0,095	0,4514	0,5461	60	Seoul	0,0103	0,9897

At the beginning of the ELECTRE approach, consistency matrix is generated. Inconsistency arises once the consistency matrix is built. This is followed by a calculation of the evaluation matrix values for each cell. For each city, the dominance values are calculated by adding together the row and column values. At the end, each city's row and column difference data are listed in decreasing order. Consequently, an ELECTRE ranking is generated. Table 10 displays the values and their respective listing order.

Table 10. Dominance table and ELECTRE ranking.

Cities	Dominance on Line (L)	Dominance in the Column (C)	Difference (L-C)	Rank	Cities	Score
Adelaide	51	8	43	1	Houston	59
Amsterdam	27	32	-5	2	Dallas	57
Ankara	20	39	-19	3	Chicago	53
Antalya	33	26	7	4	Winnipeg	52
Auckland	16	44	-28	5	Edmonton	52
Berlin	13	46	-33	6	Philadelphia	49
Birmingham	35	24	11	7	Calgary	48
Boston	35	24	11	8	Phoenix	46
Bratislava	11	48	-37	9	Adelaide	43
Brisbane	35	24	11	10	Christchurch	41
Budapest	7	52	-45	11	Ottawa	39
Calgary	53	5	48	12	Washington	37
Chicago	56	3	53	13	Rotterdam	35
Christchurch	50	9	41	14	Dublin	33
Cologne	9	50	-41	15	Kiev	29
Dallas	58	1	57	16	Den Haag	27
Dublin	43	16	27	17	San Diego	27
Edmonton	46	13	33	18	Los Angeles	25
Gothenburg	55	3	52	19	Odessa	25
Hamburg	9	50	-41	20	San Francisco	21
Houston	5	54	-49	21	Reykjavik	21

Istanbul	59	0	59	22	Perth	17
Izmir	24	35	-11	23	Brisbane	11
Kiev	28	31	-3	24	Boston	11
Lisbon	44	15	29	25	Birmingham	11
Ljubljana	26	33	-7	26	Manchester	11
London	13	47	-34	27	Antalya	7
Los Angeles	14	45	-31	28	New York	7
Luxembourg	42	17	25	29	Riga	5
Manchester	6	53	-47	30	Montreal	-1
Melbourne	35	24	11	31	Izmir	-3
Montreal	20	40	-20	32	Amsterdam	-5
Munich	29	30	-1	33	Saint Helier	-5
New York	1	58	-57	34	Yekaterinburg	-7
Nizhny	33	26	7	35	Lisbon	-7
Odessa	20	39	-19	36	Istanbul	-11
Ottawa	42	17	25	37	Tallinn	-17
Perth	49	10	39	38	Ankara	-19
Philadelphia	38	21	17	39	Nizhny Novgorod	-19
Phoenix	52	3	49	40	Melbourne	-20
Prague	52	6	46	41	Sydney	-22
Reykjavik	2	57	-55	42	Vancouver	-22
Riga	40	19	21	43	Santiago	-25
Rotterdam	32	27	5	44	Toronto	-26
Saint Helier	47	12	35	45	Auckland	-28
Saint Petersburg	27	32	-5	46	Saint Petersburg	-29
San Diego	15	44	-29	47	London	-31
San Francisco	43	16	27	48	Berlin	-33
Santiago	40	19	21	49	Ljubljana	-34
Seoul	17	42	-25	50	Bratislava	-37
Stockholm	0	59	-59	51	Gothenburg	-41
Sydney	4	55	-51	52	Cologne	-41
Tallinn	19	41	-22	53	Budapest	-45
Den Haag	21	38	-17	54	Luxembourg	-47
Toronto	17	43	-26	55	Hamburg	-49
Vancouver	19	41	-22	56	Stockholm	-51
Vienna	3	56	-53	57	Vienna	-53
Washington	48	11	37	58	Prague	-55
Winnipeg	55	3	52	59	Munich	-57
Yekaterinburg	26	33	-7	60	Seoul	-59

Houston has the greatest value in terms of the parameters, according to the ranking. The remaining four cities in the top five are Dallas, Chicago, Winnipeg, and Edmonton. Seoul, Vienna, Prague, and Munich get the lowest scores.

As a consequence of city rankings derived from the MAUT analysis and those derived from the SAW analysis are identical. Table 11 shows the benefits scores and city rankings of the MAUT study.

Table 11. Ranking and benefit values of countries according to MAUT analysis.

Rank	Cities, Countries	Ux	Rank	Cities, Countries	Ux

1	Houston, TX, United States	0.98095	31	Antalya, Turkey	0.23832
2	Dallas, TX, United States	0.94114	32	Saint Helier, Jersey	0.22815
3	Philadelphia, PA, United	0.65859	33	Melbourne, Australia	0.22701
4	Chicago, IL, United States	0.63008	34	Tallinn, Estonia	0.22496
5	Winnipeg, Canada	0.59406	35	Izmir, Turkey	0.21879
6	Edmonton, Canada	0.56194	36	Istanbul, Turkey	0.21215
7	Calgary, Canada	0.55764	37	Yekaterinburg, Russia	0.20861
8	Phoenix, AZ, United States	0.55501	38	Vancouver, Canada	0.20731
9	Adelaide, Australia	0.47828	39	Toronto, Canada	0.20698
10	Christchurch, New Zealand	0.47137	40	Nizhny Novgorod,	0.20596
11	Washington, DC, United	0.46056	41	Berlin, Germany	0.20544
12	Ottawa, Canada	0.42846	42	Sydney, Australia	0.20330
13	Rotterdam, Netherlands	0.38113	43	Lisbon, Portugal	0.20039
14	Dublin, Ireland	0.37799	44	Gothenburg, Sweden	0.19209
15	San Diego, CA, United	0.37314	45	Ankara, Turkey	0.18631
16	Los Angeles, CA, United	0.36273	46	Auckland, New Zealand	0.18544
17	Den Haag, Netherlands	0.34539	47	Cologne, Germany	0.18481
18	Perth, Australia	0.34253	48	London, United	0.17636
19	San Francisco, United	0.33029	49	Ljubljana, Slovenia	0.17445
20	Reykjavik, Iceland	0.32180	50	Saint Petersburg, Russia	0.17183
21	Brisbane, Australia	0.31019	51	Santiago, Chile	0.17015
22	Birmingham, United	0.30105	52	Bratislava, Slovakia	0.16805
23	Kiev, Ukraine	0.29488	53	Hamburg, Germany	0.16310
24	Manchester, United	0.29238	54	Luxembourg,	0.15312
25	Boston, MA, United States	0.29168	55	Stockholm, Sweden	0.14873
26	Odessa (Odesa), Ukraine	0.27771	56	Budapest, Hungary	0.14228
27	Riga, Latvia	0.27054	57	Vienna, Austria	0.13697
28	New York, NY, United	0.26925	58	Prague, Czech Republic	0.10693
29	Montreal, Canada	0.25881	59	Munich, Germany	0.10592
30	Amsterdam, Netherlands	0.23931	60	Seoul, South Korea	0.00619

In the data mining classification technique of hierarchical clustering analysis, the dendrogram was achieved by analyzing the data relating to seven criteria. After evaluating the dendrogram, it was determined to categorize the cities into four groups using k-means clusters analysis.

Table 12 presents the cluster memberships of cities according to K-means clusters analysis.

Table 12. Cluster memberships of cities according to K-means clusters analysis.

City	Cluster	Distance	City	Cluster	Distance
Dallas	1	0.104	Odessa	3	0.300
Houston	1	0.104	Kiev	3	0.290
Christchurch	2	0.192	Riga	3	0.120
Adelaide	2	0.182	Birmingham	3	0.088

Phoenix	2	0.073	Manchester	3	0.144
Washington	2	0.288	Ankara	4	0.215
Chicago	2	0.253	Auckland	4	0.049
Philadelphia	2	0.606	Prague	4	0.175
Ottawa	2	0.318	Bratislava	4	0.028
Calgary	2	0.220	Sydney	4	0.089
Winnipeg	2	0.420	Melbourne	4	0.182
Edmonton	2	0.202	Seoul	4	0.460
Istanbul	3	0.319	Tallinn	4	0.151
Izmir	3	0.241	Stockholm	4	0.096
Antalya	3	0.210	Gothenburg	4	0.138
Brisbane	3	0.173	Vancouver	4	0.115
Perth	3	0.267	Toronto	4	0.106
Amsterdam	3	0.180	S. Petersburg	4	0.199
Den Haag	3	0.182	Yekaterinburg	4	0.172
Rotterdam	3	0.259	Luxembourg	4	0.070
New York	3	0.089	Ljubljana	4	0.033
Los Angeles	3	0.192	Vienna	4	0.111
Boston	3	0.061	Budapest	4	0.080
San Francisco	3	0.120	Berlin	4	0.134
San Diego	3	0.260	Munich	4	0.195
Saint Helier	3	0.184	Hamburg	4	0.122
Reykjavik	3	0.083	Cologne	4	0.094
Montreal	3	0.216	Santiago	4	0.159
Nizhny Novgorod	3	0.264	Lisbon	4	0.175
Dublin	3	0.263	London	4	0.093

The results of the Borda Count technique are presented in Table 13.

Table 13. Ranking of cities according to Borda Count Method

Rank	City	Borda Score	Rank	City	Borda Score
1	Houston	51.625	31	Antalya	25.375
2	Dallas	50.75	32	Saint Helier	23.875
3	Philadelphia	49.5	33	Melbourne	22.875
4	Chicago	49.125	34	Tallinn	22.5
5	Winnipeg	48.25	35	Izmir	21.5
6	Edmonton	47.375	36	Yekaterinburg	19.375
7	Calgary	46.375	37	Istanbul	19.25
8	Phoenix	45.5	38	Vancouver	18.5
9	Adelaide	44.625	39	Toronto	18.125
10	Christchurch	43.75	40	Nizhny Novgorod	17.25
11	Washington	42.75	41	Berlin	17
12	Ottawa	42.125	42	Sydney	16.875
13	Rotterdam	41	43	Lisbon	16.375
14	Dublin	40.125	44	Gothenburg	14
15	San Diego	39.375	45	Ankara	13.25

16	Los Angeles	38.25	46	Auckland	12.375
17	Perth	36.5	47	Cologne	11.75
18	San Francisco	35.75	48	London	10.625
19	Reykjavik	34.625	49	Ljubljana	9.375
20	Brisbane	33.875	50	Santiago	9.25
21	Kiev	32.625	51	Saint Petersburg	8.625
22	Birmingham	32.625	52	Bratislava	7.5
23	Den Haag	32.25	53	Hamburg	7.125
24	Manchester	31.375	54	Luxembourg	5.5
25	Boston	30.875	55	Stockholm	4.375
26	Odessa	30.375	56	Budapesty	3.75
27	Riga	29	57	Vienna	2.875
28	New York	28.125	58	Prague	1.5
29	Montreal	27.5	59	Munich	1.125
30	Amsterdam	25.625	60	Seoul	0

The top-performing cities in terms of property price indicators, according to the findings of the assessments, are Houston, Dallas, Philadelphia, Chicago, Winnipeg, Edmonton, Calgary, Phoenix, Adelaide, and Christchurch, respectively. When the cities with low performance scores are evaluated, Seoul ranked last in the rankings obtained from all methods used in this research. When evaluating poor performing cities in general, Saint Petersburg, Bratislava, Hamburg, Luxembourg, Stockholm, Budapest, Vienna, Prague, Munich, and Seoul, are at the last ten in almost all rankings. In the rankings, there is not a single city from the European continent among the top ten cities. Five of the top ten cities are from the USA, three from Canada, and one each from Australia and New Zealand. Also, in the rankings, all cities in the last ten cities except Seoul are from the European continent.

4. Discussion

As a new approach to property market evaluation, this research employed multi-criteria decision making approaches to examine the present state of the 60 cities in the 25 nations throughout the world.

Indicators of the price of real estate are at odds with one another. When it comes to making decisions in this area, it's important to apply multi-criteria methodologies. New methodologies were operated in this research to call attention to the rise in home prices and deterioration in affordability throughout the globe. In terms of this issue, data mining cluster analysis combined with MCDM approaches is a novelty offered by this research.

Descriptive statistical approaches are often used to analyze nations in research of a similar kind. Using eight MCDM approaches and cluster analysis, we were able to get findings that are usually similar among the 60 cities studied from 25 nations. Also, these MCDM approaches do not include any kind of subjective judgment in their computations.

PROMETHEE is quite stronger than other approaches when it comes to visualizing both similarities and differences between cities and nations, as well as between groupings of countries. Because of this, it sticks out a little more visually than in other ways. In the comprehensive evaluation, the ranks of all of the approaches are quite consistent with one another.

There may be huge discrepancies in findings across assessments of the same indicators when using MCDM approaches such as the Analytic Network Process (ANP) or the Analytic Hierarchy Process (AHP). Also, for the same indications, the findings will change if the criteria weights are established by subjective judgements. It was decided to apply the MCDM and cluster analysis methodologies in this investigation, and the criteria were objectively weighted and did not need any subjective judgment. To put it another way, the assessments were conducted in a manner that was absolutely unbiased. There are some discrepancies in the rankings because of the computational variances across the approaches. Overall evaluations, however, show that all techniques yielded findings that were comparable to one another and to other rankings of methods.

Numerous research has been done on the topic of determining and comparing the most developed nations in terms of property prices and affordability. In the introduction section, MCDM analyses that had been done on this or related themes in the previous five years were evaluated. The breadth, techniques, and number of nations included in this research set it apart from previous efforts on the subject. This is evident when looking at the number of studies, methodologies, and applications that have gone before it. Different approaches to solving this issue might be proposed for future research, and the results could be compared to those found in this article. This research should be repeated in the coming years to assess and compare the property market performance of these nations.

5. Conclusion

The article evaluates 60 cities from 25 countries, mostly European, based on 7 indicators related to property market. In addition, while the article aims to demonstrate the current status of these countries, it also aims to offer an integrated decision support framework in order to contribute to this field. Indicators used in the application of study include very important topics in terms of sustainable welfare state, economy and property market of countries. The fact that a city has a poor score in terms of property price index criteria also means that the stability and sustainability of that country's economy, welfare of citizens, life quality, economic jus-tice, sustainable growth, and employment opportunities are under threat.

Among the top ten cities in the all analyses, Houston is the best city in terms of property price and affordability. Also, Dallas is the second on the all lists. According to the final ranking obtained from the Board Count method, five of the top ten cities performing best in terms of the relevant criteria are in the USA, three in Canada, and one each in Australia and New Zealand. According to the results of the analysis, only the cities of Rotterdam, Dublin and Reykjavik from the European continent managed to be among the top twenty cities in the ranking. Seoul is the worst performing country in all rankings. When an evaluation is made in terms of the last ten countries, all of them are European cities except Seoul. Considering the 25 countries included in the analysis, the USA is way ahead of other countries in terms of property prices and affordability by a significant margin. Cities such as New York and Boston, on the other hand, lag far behind other US countries included in the analysis. They are quite different from other US cities in the evaluation in terms of affordability and pri-ce-to-income ratios. As stated in the introduction, when an evaluation is made in terms of Turkey, the country where inflation and housing prices increased the most in the last 4 quarters, the five Turkish cities included in the study are in the middle of the rankings. It is understood that it is still in a better position in terms of income and price ratio and affordability compared to many European countries. According to the results of the study, German cities also perform poorly compared to most cities in the assessment.

Seoul, which is the last in all rankings, needs to be evaluated separately. House prices in South Korea have been rising steadily since 2014 and it is getting harder and harder to buy a house. The median price of homes in Seoul, where half of Koreans live and where many businesses are located, is around $792,800, compared to the country's per capita income of $32,047. The ratio of household debt to net income in the country is 180%, the highest level among OECD countries. The government, which is wary of the house price bubble and has been trying for a long time to stop the speculation with more than 20 cooling policies introduced by President Moon Jae-in, has also set the upper limit of the loan to house value ratio for houses valued below 900 million won at 40%. This means that those who want to buy a house can take out a loan of up to 40% of the value of the house. The apparently rising real estate prices are deeply linked to structural problems in the South Korean economy.

Inflation is increasing rapidly in almost every country, mainly due to pandemic-related reasons. Rising inflation rates have led people to invest in the raw material market, energy, real estate, and even old cars in order not to lose their capital. While this caused real estate prices to increase rapidly, it also destroyed the dreams of low and middle income group citizens to own a house. These developments caused the increase in housing rents to increase at an unbearable rate. People living in Turkey, New Zealand, Slovakia, South Korea, and some crowded US states where housing supply is lower than demand and prices are increasing extremely have largely lost their hope of owning a house. According to the rankings in the analysis, especially citizens living in Eastern European countries experience great problems due to housing market prices and insufficient income.

Considering the negative repercussions resulting from the Coronavirus, which cast a shadow over most countries over the world, the presence of positive rates in Turkey in terms of a high growth rate with a noticeable increase in exports in general, in addition to the continuous development in various industries. But on the other hand, the Turkish lira is suffering from an undisputed decline, and due to the instability of the exchange rate, many dealers with Turkey have recalculated over and over, the result of this conflict was high inflation rates, which have negative repercussions (economically and socially), especially on the real estate sector in Turkey.

The war between Russia and Ukraine also has repercussions on energy prices, and this puts upward pressure on the CPI. In this case, of course, it affects countries that do not produce the necessary policies against high inflation. It is seen that the expansionary policies pursued in the world and the increase in global demand are pushing prices up. While this situation provides an upward movement in raw material prices, it negatively affects the housing market. Rising food prices and energy costs also reduce households' ability to save money. This makes it impossible for people with low and middle income to own a house.

In countries such as Turkey, Germany, and South Korea, many policies implemented by governments regarding housing, unfortunately, do not contribute to the supply of affordable housing to low- and middle-income people. When the indicator values in the study are evaluated, there is a great mismatch between property prices and rents. It is obvious that there is a price bubble in the cities where the rental income is quite low compared to the purchase price in the city center or outside. In this regard, it is understood that the policy makers of the relevant cities need to create more effective structural action plans.

Globally, current economic parameters and developments show that these extraordinary increases in property prices and the inadequacy of incomes to meet these prices will continue for a while. It is understood that people with low and middle income will continue to have this problem in terms of shelter, which is the most basic need of human beings after nutrition, whether they live in one of the most developed countries in the world or in a developing country. There is a need for an affordable housing supply, fair income distribution and wage policy in order to enable sustainable quality of life in many countries, especially in the most populated cities. It is expected that awareness of housing problems, which is an important dimension of sustainable life quality in the world, will increase and more effective policies will be created with the increase of this and similar studies.

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