MULTIDIMENSIONAL ANALYSIS OF REAL ESTATE PRICES IN SEVENTEEN CITIES IN POLAND IN TERMS OF ECONOMIC SECURITY

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Abstract. The article presents a multidimensional comparative analysis of apartment prices in seventeen cities in Poland from the first quarter of 2017 to the first quarter of 2021 in terms of the maintenance of economic security. Prices were analyzed in two aspects: value and dynamics of changes, referring to the first period under consideration in spatial terms (in each of the seventeen cities). The research used multidimensional comparative analyzes, such as: Chernoff faces and normalization with the use of stimulants. This, in turn, made it possible to examine the similarities and differences in the prices of 1 m2 of residential real estate in respective cities in Poland in a dynamic approach.

1. Introduction

In 2020, when the COVID-19 pandemic began, there was a belief that housing prices would drop significantly in the near future. Eventually, when analyzing the years 2020-2021, this did not happen (Rynek Nieruchomości a Covid-19, 2021, see Jurgilewicz, Spalińska, 2021). The price is one of the economic categories that determines the size of the purchase and sale transactions for apartments on the real estate market. In the literature, it is defined as the value of a good, service, currency or production factor expressed in money (Owsiak 2015, p. 344, Jurgilewicz et al., 2021). In respective cities in Poland, the prices of 1 m2 of living space vary considerably. They result from various factors including the aspect related to tourism. Apartment prices will be higher at the seaside, lake or in the mountains. Another factor determining the price is the size of the population in the city including, but not limited to, access to jobs, schools, colleges and airports. This became the premise for the formulation of the research problem of the study, which is: To what extent will the formulation of a multidimensional comparative analysis including stimulants allow for the ranking of prices for 1 m2 of residential space on the secondary real estate market in seventeen cities in Poland dynamically in terms of the maintenance of economic security during the impact of the COVID-19 pandemic?

The aim of the study is to rank the prices of 1 m2 of residential space in seventeen cities in Poland during the period of the COVID-19 pandemic impact on a quarterly basis from the first quarter of 2017 to the first quarter of 2021.

A research hypothesis was formulated for the research problem and the aim of the study:

The use of a multidimensional comparative analysis including stimulants will allow to examine the similarities and differences in the prices of 1 m2 of living space in seventeen cities in Poland in individual periods from the first quarter of 2017 to the first quarter of 2021.

The following research methods were used in the article: multidimensional comparative analysis, such as: Chernoff faces, normalization for stimulants.

2. Analysis of the literature on the research subject

The infectious disease COVID-19 has brought changes in the functioning of respective sectors of the world's economies (Okunola, Fakunle, 2021; Periokaite, Dobrovolskiene, 2021; Phuong, 2021).

These changes were also visible on the real estate market. The first case of COVID-19 was observed in December 2019 in Wuhan, China (Zhu, Zhang, et al., January 24, 2020). The disease showed a rapid tendency to spread and endangered human life and health. This in turn led to the World Health Organization's declaration of the COVID-19 pandemic on March 11, 2020 (Satomi, et al., April 2020). By February 17, 2022, approximately 5 460 552 people in Poland had been infected and 109 205 died (Coronavirus (COVID-19), 2022).

The pandemic has led to the introduction of many restrictions by respective countries of the world (Matuka, 2020), such as the ban on movement and the possibility of distant work in the initial stage of the emergence of the disease. This had a direct impact on the prices on the real estate market in Poland in terms of purchase and hiring. Thanks to distance learning, students returned home and did not have to rent flats, the loss of jobs also caused an outflow of people from the cities and postponement of possible decisions to buy a flat.

The prices of flats in respective voivodeships in Poland between 2015-2020 were and are varied, and in total they show a growing trend (Kozicki, Mitkow, Sowa, 2021), especially in large urban agglomerations, such as: Warsaw, Gdańsk and Kraków.

The number of real estate purchase and sale transactions in Poland and around the world is influenced by many factors including unemployment, mortgage interest rates and others resulting, for instance, from the geopolitical situation of respective countries or regions. The COVID-19 pandemic undoubtedly had an impact on world prices in the real estate market. In April 2020, it led to a huge increase in the unemployment rate in the largest economy in the world which is the United States - to 14,6% (April 2020) from 3,6% recorded in January 2020 (Kozicki, Mitkow, 2021, p. 167-181; Business Insider, 2020; money.pl, 2021).

Poland did not experience such a strong increase in unemployment rates during the COVID-19 pandemic as in the United States (*Rynek pracy w czasie pandemii*, 2021). On the other hand, in 2020, an increase in apartment prices was observed by about 8% compared to 2019 (Dziennik Gazeta Prawna, 5/10/2021; Murator Plus, 2021). Housing prices in Poland increased by as much as 10% during 2021 (*Rynek mieszkaniowy 2021. Prognozy na 2022*, 2021). Over the past fifteen years, the arithmetic mean of housing prices in Poland increased most in the EU. The price of an apartment in Poland, which in 2005 cost PLN 200 000, increased in 2020 to over PLN 480 000 (Money.pl, 2021; Business Insider, 2021).

The article attempts to analyze housing prices on the secondary market. The research in the study was based on multidimensional comparative analyzes (Panek, Zwierzchowski, 2013, p. 15, Łuniewska, Tarczyński, 2006, p. 9) including the Chernoff faces. This technique is considered in many cases the most advanced multidimen-

sional exploratory technique that shows hidden interrelationships between variables that cannot be detected otherwise.

The stimulants were also normalized (Mitkow, Tomaszewski, Kozicki, 2021, pp. 110-160). A stimulant is a form of data normalization based on the assumption that the higher the value of the stimulant, the higher its rank. The research on the prices of 1 m2 of residential space on the secondary market was conducted in terms of economic security observation.

Security in literature is divided according to several criteria (Brzeziński, 2009, pp. 33-34; Grabowski, 2009, pp. 95-104). They include: political, military, economic, environmental, social ones, etc. (Wojtaszczyk, 2009, p. 12; Masood, Javaria, Petrenko, 2020; Chehabeddine, Tvaronavičienė, 2020; Beňuška, Nečas, 2021; Khalatur et al., 2021).

The study focuses on economic security. According to Nurzyńska, economic security is the certainty of the survival and development of the economic system of the state and international economic organizations, it guarantees the maintenance of an appropriate position in economic relations and a proper standard of living for citizens (Nurzyńska, 2016, p. 22). Kitler, on the other hand, believes that economic security is related to the ensuring of the economic conditions necessary for the survival, prosperity and sustainable development of society and the efficient functioning of the state and its institutions (Kitler, 2011, p. 49). One of the forms of the ensuring of the economic security of respective countries is providing citizens with access to real estate, including housing. An important aspect is also the price of 1 m2 of residential space and its fluctuations which affect the size of the demand and supply of real estate in dynamic terms. The study attempts to analyze them by examining the similarities and differences in seventeen cities in Poland between 2017-2021.

3. Multidimensional analysis of real estate prices on the secondary market in Poland

The research began with a categorized bar chart of the arithmetic mean of prices for 1 m2 of residential space on the secondary market in seventeen cities in Poland on a quarterly basis from the first quarter of 2017 to the first quarter of 2021.
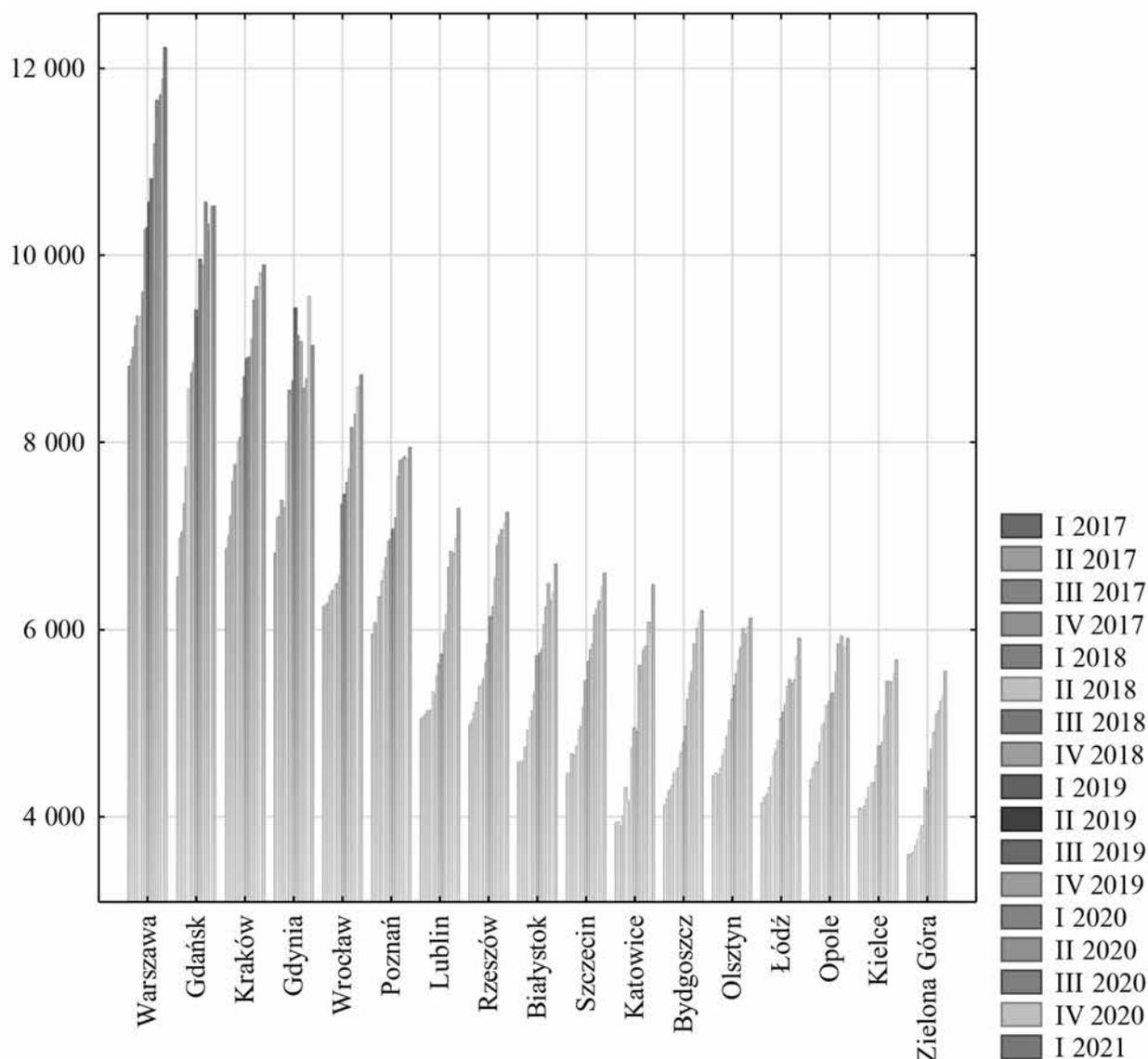
Figure 1. Categorized bar graph of the arithmetic mean of prices for 1 m2 of residential space on the secondary market in 17 cities in Poland on a quarterly basis from the first quarter of 2017 to the first quarter of 2021

Source: own study based on data from the website: https://www.nbp.pl; as of 02/16/2022

The data in Figure 1 shows that the highest apartment prices in the period from the first quarter of 2017 to the first quarter of 2021 in Poland were in Warsaw. The ranking of cities in terms of the highest price of 1 m2 of residential space on the secondary market in the first quarter of 2021 was as follows (price in PLN): 1. Warsaw: 12216,88; 2. Gdańsk: 10528,83; 3. Krakow: 9899,14; 4. Gdynia: 9029,10; 5. Wrocław: 8715,21; 6. Poznań: 7942,59; 7. Rzeszów: 7246,23; 8. Lublin: 7285,15; 9. Białystok: 6700,23; 10. Szczecin: 6609,49; 11. Olsztyn: 6130,25; 12. Opole: 5900,05; 13. Bydgoszcz: 6201,25; 14. Łódź: 5904,63; 15. Katowice: 6486,93; 16. Kielce: 5671,22; 17. Zielona Góra: 5557,80.

Then, Figure 2 shows the differences between the price of 1 m2 of residential space on the secondary market in the first quarter of 2021 and the first quarter of 2017.
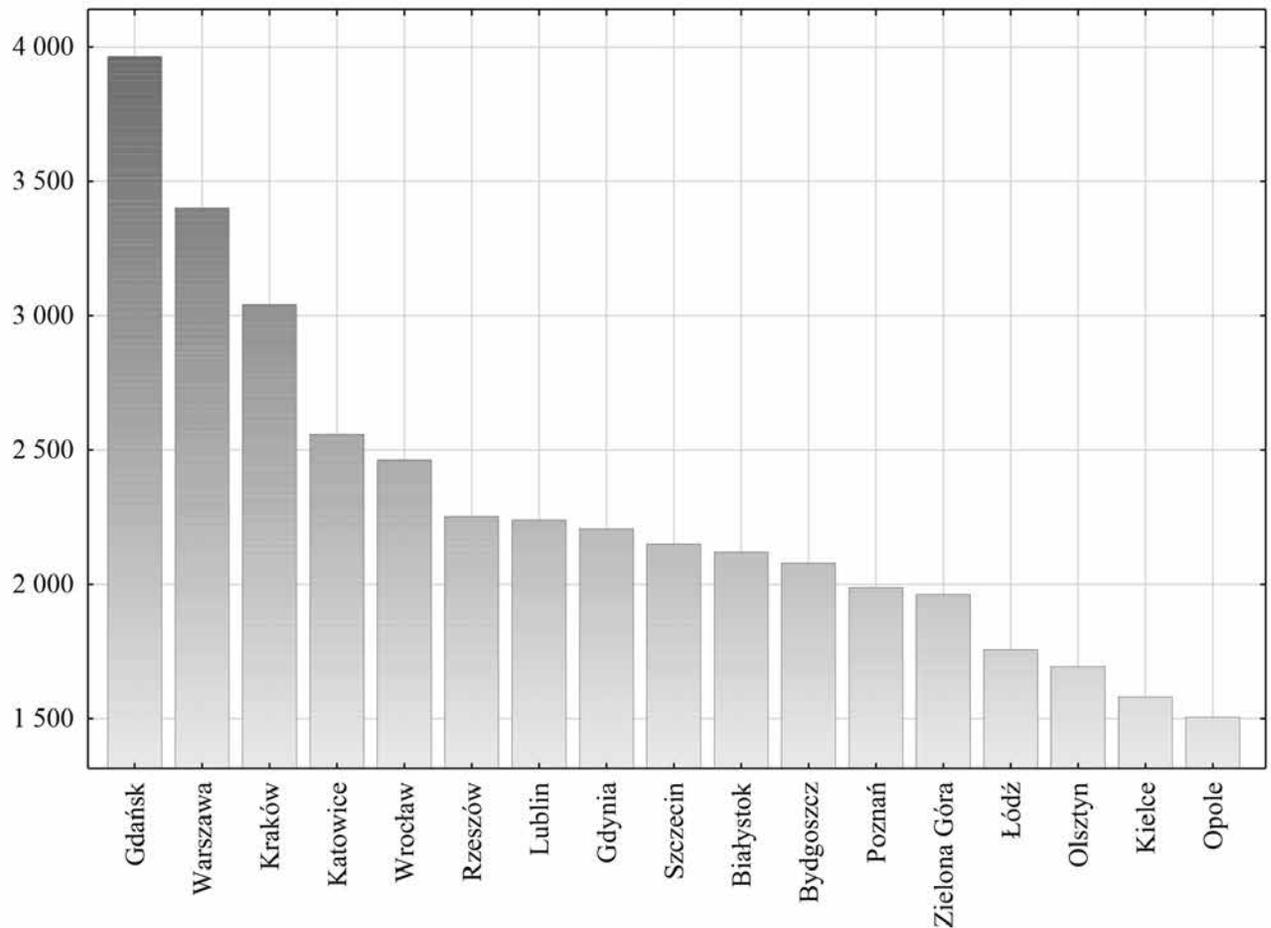
Figure 2. Categorized bar chart of the price difference of 1 m2 of residential space on the secondary market
in 17 cities in Poland between the first quarter of 2021 and the first quarter of 2017

Source: own study based on data obtained from the website: https://www.nbp.pl; as of 02/16/2022

The analysis shows that the ranking of cities in terms of the increase in the price of 1 m2 of residential space
on the secondary market in 17 cities in Poland between the first quarter of 2021 and the first quarter of 2017 is
as follows: 1. Gdańsk: 3963,16; 2. Warsaw: 3401,15; 3. Krakow: 3040,00; 4. Katowice: 2557,50; 5. Wrocław:
2462,21; 6. Rzeszów: 2251,23; 7. Lublin: 2238,15; 8. Gdynia: 2206,65; 9. Szczecin: 2148,13; 10. Białystok:
2120,23; 11. Bydgoszcz: 2078,25; 12. Poznań: 1987,71; 13. Zielona Góra: 1961,80; 14. Łódź: 1755,63;
15. Olsztyn: 1693,63; 16. Kielce: 1580,18; 17. Opole: 1505,31.

The next stage of the research was the analysis of the price dynamics of 1 m2 of residential space on the second-
ary market in seventeen cities in Poland from the first quarter of 2017 (Fig. 3).
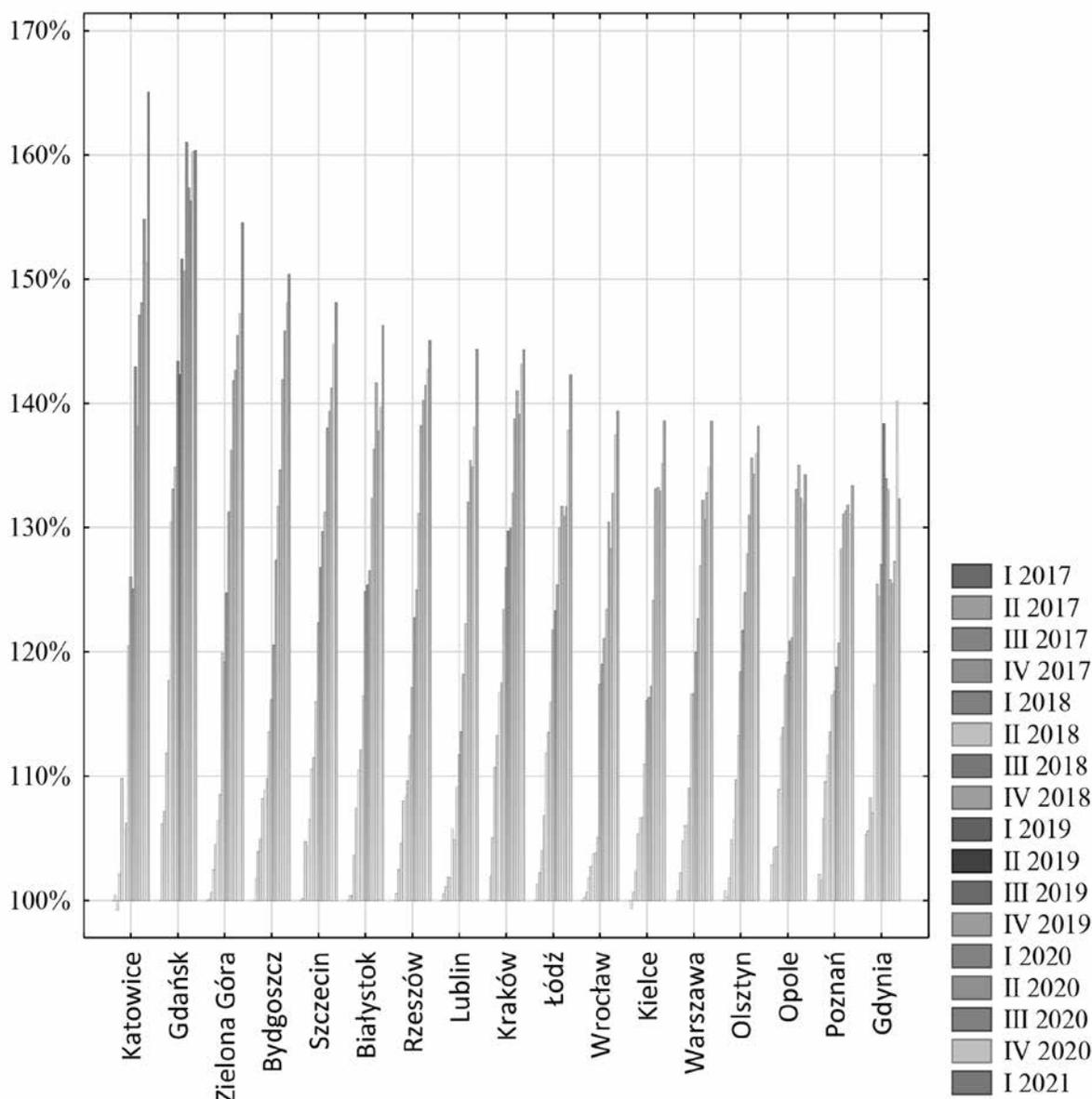
Figure 3. Categorized bar chart of dynamics indices on a constant basis of an arithmetic mean of prices for 1 m2
of residential space on the secondary market in seventeen cities in Poland on a quarterly basis
from the first quarter of 2017 to the first quarter of 2021

Source: own study based on data obtained from the website: https://www.nbp.pl; as of 02/16/2022

The research on the dynamics of changes in the price of 1 m2 of residential space in Poland on the secondary market shows that from the first quarter of 2017 to the first quarter of 2021, the largest increase was noticeable in the following cities: 1. Katowice: 65,09%; 2. Gdańsk: 60,36%; 3. Zielona Góra: 54,55%; 4. Bydgoszcz: 50,41%; 5. Szczecin: 48,15%; 6. Białystok: 46,29%; 7. Rzeszów: 45,07%; 8. Lublin: 44,35%; 9. Krakow: 44,32%; 10. Łódź: 42,31%; 11. Wrocław: 39,38%; 12. Kielce: 38,63%; 13. Warsaw: 38,58%; 14. Olsztyn: 38,17%; 15. Opole: 34,25%; 16. Poznań: 33,38%; 17. Gdynia: 32,34%.

The next stage of the research was the application of normalization for the stimulant of the arithmetic mean of prices for 1 m2 of residential space on the secondary market in seventeen cities in Poland on a quarterly basis from the first quarter of 2017 to the first quarter of 2021 (Fig. 4).
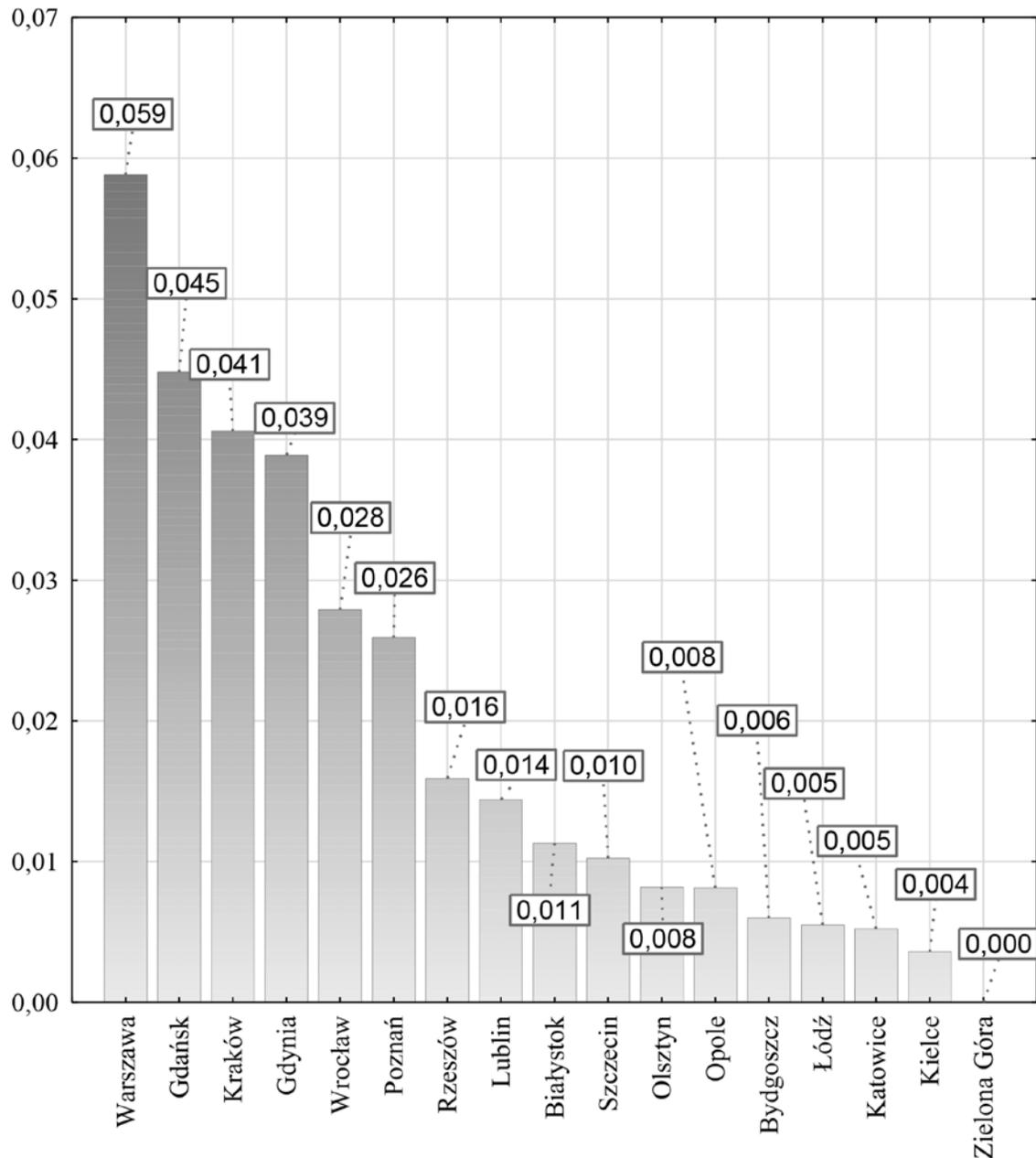
Figure 4. Ranking of the arithmetic mean of prices for 1 m2 of residential space on the secondary market
in 17 cities in Poland on a quarterly basis from the first quarter of 2017 to the first quarter of 2021
with the use of the standardization for the stimulant

Source: own study based on data obtained from the website: https://www.nbp.pl; as of 02/16/2022

The conducted research shows that after the application of the normalization for the stimulant of the arithmetic mean of prices for 1 m2 of residential space on the secondary market in seventeen cities in Poland on a quarterly basis from the first quarter of 2017 to the first quarter of 2021, ten groups of dependent variables were observed in which there are explanatory variables close to each other (groups were ranked from the highest to the lowest value):

1 – Warszawa: 0,059;
2 – Gdańsk: 0,045;
3 – Kraków: 0,041; Gdynia: 0,039;
4 – Wrocław: 0,028; Poznań: 0,026;
5 – Rzeszów: 0,016; Lublin: 0,014;
6 – Białystok: 0,011; Szczecin: 0,010;

7 – Olsztyn: 0,008; Opole: 0,008;
8 – Bydgoszcz: 0,006; Łódź: 0,005; Katowice: 0,004;
9 – Kielce: 0,004;
10 – Zielona Góra: 0,000.

In the dependent variable group 1, the purchase price of 1 m2 in the period from the first quarter of 2017 to the first quarter of 2021 was the highest one and in the last positions it was successively lower.

The next stage of the research was the use of multidimensional data analysis to compare the prices of 1 m2 of residential space in Poland in respective periods from the first quarter of 2017 to the first quarter of 2021 in seventeen cities in Poland. Chernoff faces were used for this. The facial features were assigned to the prices of 1 square meter of living space in respective quarters: face width = first quarter 2017; ear level = second quarter 2017; half of the face height = third quarter 2017; upper half of the face - excess = fourth quarter 2017; lower half of the face - excess = first quarter 2018; nose length = second quarter 2018; concentricity of the mouth = third quarter 2018; mouth curving = fourth quarter 2018; mouth length = first quarter 2019; ear height = second quarter 2019; eye gap = third quarter 2019; eye slant = fourth quarter 2019; excess - eyes = first quarter 2020; eye length = second quarter 2020; pupil level = third quarter 2020; eyebrow height = fourth quarter 2020; brow angle = first quarter 2021.
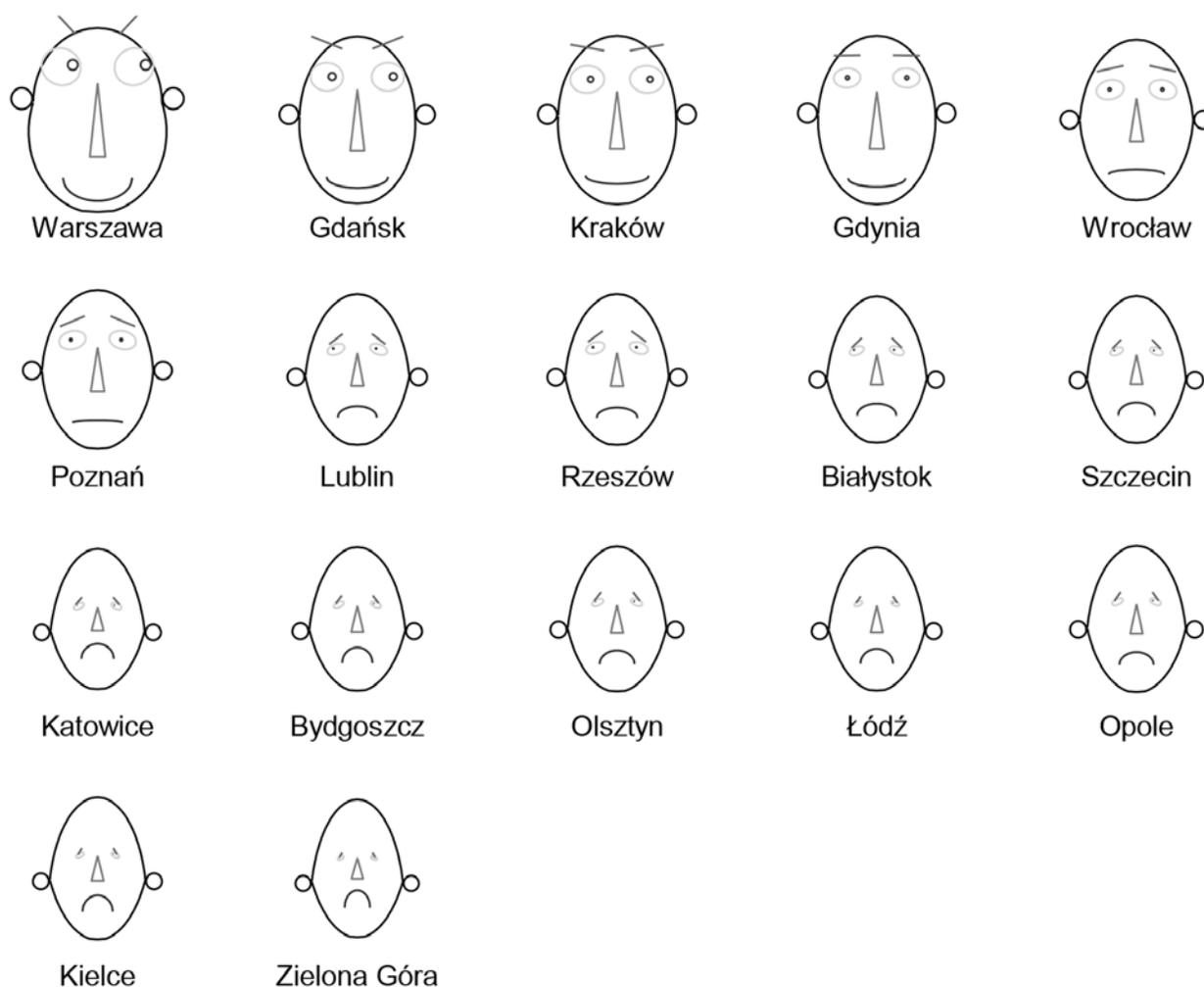

Figure 5. Chernoff faces of the arithmetic mean of prices for 1 m2 of residential space on the secondary market in 17 cities in Poland on a quarterly basis from the first quarter of 2017 to the first quarter of 2021

Source: own study based on data obtained from the website: https://www.nbp.pl; as of 02/16/2022

Research with the use of multidimensional data analysis, such as Chernoff faces, shows that Warsaw is a city that stands out from the others in terms of the highest prices of 1 m2 of residential space on the secondary market. The next three cities with prices per square meter lower than Warsaw are: Gdańsk, Kraków and Gdynia. These cities are close to each other. There was also a similarity between two cities with prices per m2 lower than in the previous group: Wrocław and Poznań. The similarity can also be seen in Lublin and Rzeszów. Another group of similar cities is: Białystok, Szczecin, Katowice, Bydgoszcz, Olsztyn, Łódź, Opole and Kielce. The lowest one in the classification in terms of prices of 1 m2 of residential space on the secondary market in Poland of the 17 analyzed cities - with the smallest face - is Zielona Góra.

4. Summary and conclusions

The COVID-19 pandemic has affected the real estate market in Poland. At the beginning of the pandemic, the Monetary Policy Council in Poland, wishing to ensure the economic security of citizens, decided to lower the required reserve rate from 3,50% to 0,50%, and to increase the interest rate on funds kept as the required reserve from 0,50% to the level of NBP reference rate (*Rynek nieruchomości a COVID-19*, 2021). This, in turn, has led to a reduction in the financial resources needed to cover borrowers' financial debts. In the real estate market in Poland, from 2017 to 2021, further continuous increases in real estate prices, including apartments, were observed. The research shows that the highest prices of flats in the seventeen analyzed cities in Poland on the secondary market, from the first quarter of 2017 to the first quarter of 2021 in Warsaw, remained with a price of PLN 12 216,88. The following cities with the highest price are (in PLN): 2. Gdańsk: 10528,83; 3. Krakow: 9899,14; 4. Gdynia: 9029,10; 5. Wrocław: 8715,21; 6. Poznań: 7942,59; 7. Rzeszów: 7246,23; 8. Lublin: 7285,15; 9. Białystok: 6700,23; 10. Szczecin: 6609,49; 11. Olsztyn: 6130,25; 12. Opole: 5900,05; 13. Bydgoszcz: 6201,25; 14. Łódź: 5904,63; 15. Katowice: 6486,93; 16. Kielce: 5671,22; 17. Zielona Góra: 5557,80. Considering the value changes in the price of 1 m2 of residential space on the secondary market in seventeen cities in Poland from the first quarter of 2017 to the first quarter of 2021, it was observed that the highest increases were as follows (in PLN): 1. Gdańsk: 3963,16; 2. Warsaw: 3401,15; 3. Krakow: 3040,00; 4. Katowice: 2557,50; 5. Wrocław: 2462,21; 6. Rzeszów: 2251,23; 7. Lublin: 2238,15; 8. Gdynia: 2206,65; 9. Szczecin: 2148,13; 10. Białystok: 2120,23; 11. Bydgoszcz: 2078,25; 12. Poznań: 1987,71; 13. Zielona Góra: 1961,80; 14. Łódź: 1755,63; 15. Olsztyn: 1693,63; 16. Kielce: 1580,18; 17. Opole: 1505,31. On the other hand, the dynamics growth of the prices of 1 m2 of residential space in respective analyzed cities was as follows (constant - 1 quarter, prices of 1 m2 of residential space on the secondary market in each of the seventeen cities in Poland in 2017): 1. Katowice: 65,09% ; 2. Gdańsk: 60,36%; 3. Zielona Góra: 54,55%; 4. Bydgoszcz: 50,41%; 5. Szczecin: 48,15%; 6. Białystok 46,29%; 7. Rzeszów: 45,07%; 8. Lublin 44,35%; 9. Krakow 44,32%; 10. Łódź: 42,31%; 11. Wrocław 39,38%; 12. Kielce 38,63%; 13. Warsaw: 38,58%; 14. Olsztyn: 38,17%; 15. Opole 34,25%; 16. Poznań 33,38%; 17. Gdynia 32,34%.

The applied normalization for the stimulant allowed for ranking, including the assignment of respective cities to groups of dependent variables (groups were ranked from the highest to the lowest value):
1. Warszawa: 0,059;
2. Gdańsk: 0,045;
3. Kraków: 0,041; Gdynia: 0,039;
4. Wrocław 0,028; Poznań 0,026;
5. Rzeszów 0,016; Lublin 0,014;
6. Białystok 0,011; Szczecin 0,010;
7. Olsztyn 0,008; Opole 0,008;
8. Bydgoszcz 0,006; Łódź 0,005; Katowice 0,004;
9. Kilce 0,004;
10. Zielona Góra 0,000.

This type of observation can be used to conduct future investments in terms of the allocation of financial resources in real estates in Poland. In turn, the use of Chernoff faces showed that Warsaw is a city that stands out from the others in terms of the highest prices for 1 m2 of residential space on the secondary market. The next

three cities with prices per square meter lower than Warsaw are: Gdańsk, Kraków and Gdynia. Prices in these cities are close to each other. The predictions from the beginning of the pandemic about a decline in prices have not come true, on the contrary - housing prices have dynamically increased and are still rising. The continuous monitoring of prices on the real estate market, including in the threats such as the COVID-19 pandemic, is extremely important in terms of measures to be taken to ensure the economic security of the state and its citizens. The institution having a direct impact on changes in this respect is the National Bank of Poland which has tools that affect the interest rate on loans, the level of required reserve rates, the amount of money in circulation and others. The COVID-19 pandemic is not over yet and the effects of its impact on respective sectors of the economy, including the real estate sector, will be visible after several years.

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