Analysis of the Real Estate Market in Sofia, Bulgaria, during the COVID-19 pandemic

Marin Marinov, Ivo Draganov

Abstract — **In this paper an analysis of the real estate prices in Sofia, Bulgaria for the period from 2019 to 2021 is presented. It is based on observation of the selling rates by type of apartments – with one, two and three bedrooms, and as cumulative entity, over quartiles by 3 months periods, for representative set of neighborhoods, uniformly selected by geographical criteria from the whole city. Approximating price distributions are found on a year basis, evaluated by precision, which reveal new tendencies during the COVID-19 pandemic. Linear regression models are generated from the price series over time for 14 neighborhoods and their predicting capability has been estimated as satisfactory. These models uncover the underlying price change and its rate on a local scale within the city prior and during the pandemic. Cluster models, obtained from the K-means algorithm, of the real estate in low- and high-price groups denote the current layered structure of the market. All obtained results could be useful into building new marketing strategies of the real estate brokerage houses, adequate to the ongoing pandemic situation.**

Index Terms—**real estate, market analysis, Sofia, Bulgaria, pandemic, COVID-19**

I. Introduction

In a long time period prior the COVID-19 pandemic, there is stable increase of the total size of the deposits in Republic of Bulgaria and decrease in the interest rate of the long-term government securities – from 23.6 to 37.5 billion BGN, and from 5.5% to 2.07%, respectively [1]. According to that study, the investment in real estate in Sofia, Bulgaria, around 2016 is justified. Two years later, another study [2] takes into account the gross rental yield, price to income ratio, newly built residential units, and other parameters for analysis. A conclusion is made that the influence of the average prices for various types of living areas at that moment in the capital (around 1000 €/m^2) are promising mean for leveling up of the living standard of working people and for the improvement of the politics for steady economic development. The credit availability index and the annual gross return on rents, supporting this claim, are around 1.4 and 5.5%, respectively [2]. Just before establishing these promising rates in the real estate business, the attitudes towards institutional changes, are being evaluated, as shown in [3], with regard to all stakeholders. Estimates on the strength of the applicable formal rules from legal perspective and non-formal norms (e.g. ethical rules) over the market are connected with the competence level of experts from the brokerage companies. The established relations point towards the unstopping influence of the legal norms on buyers' behavior, but in the same time opportunistic behavior and the growing information asymmetry lead to difficulties in transferring of the residential units. As a result, the cumulative expenses and the transactions periods get higher. The quality of service is around 70% [3]. The personal judgement as positive attitude of the legal norms in the primary market reaches 62.7%, 13.7% higher than that of the secondary market [3].

Quality features of the luxury real estate in Sofia are becoming more attractive among buyers and the demand is getting ahead the offering in 2017 [4]. Two year earlier, the share among 1-, 2-, 3-, 4- and >4-room apartments is 4%, 45%, 40%, 5%, and 6%, respectively with only portion of these, described as luxurious [4]. Some of the factors for that change, according to the author of the study, are related to certain transformations in the banking sector. Another supporting process of the higher demand of real estates in Sofia could be the intense development of the outsourcing industry and the introduction of new office spaces [5]. In 2017, the contribution of that sector to the gross domestic product is 4.8%. Two years later the newly exploited business areas in the field are 70 000 m^2. Another aspect, influencing the movement in the real estate market with significant impact, is the human capital and the socio-cultural environment [6]. They are prerequisites for the social status of all customers and could be the discriminating factor for the type of real-property, being targeted. Given the increase of the Bulgarian household consumption from 44 billion BGN in 2010 to 53 billion BGN – in 2015, 1-room apartments are mainly bought as investment [6]. Permanent home usage is sought by the customers with a selection on mainly 2- and 3-room apartments. Larger living areas of at least 200 m^2 keep 2 to 4 times higher selling price [6]. At the end of 2018, the newly exploited homes by the number of rooms in Sofia is more than 500 on the primary market [7]. In the secondary one, they are more than 600 000 [7]. The most benefits, evaluated by a 7 component model, come with the purchase of a real estate from the secondary market, which is 5 to 10 years in its exploitation [7]. The investment maturity and attractiveness of the office market in the capital of Bulgaria [8], may be considered as another driver for certain deviations in the home demand rate. In 2015, there are 1 722 000 m^2 offices in Sofia, but even the almost triple increase from 2007, when they are only 673 m^2, does not imply proportionally growing new investments [8]. During new studies, certain saturation levels may be looked for as per the influence of the demand for living areas from workers,

This work was supported by the contract № 212PD0006-07 for research project: "Analysis of the transformation of the financial indicators in the conditions of COVID-19 pandemic" of the Technical University of Sofia, Research and Development Sector.

M. Marinov is with the PhD School, French Faculty of Electrical Engineering, Technical University of Sofia, 8, Kliment Ohridski Blvd., 1756 Sofia, Bulgaria (e-mail: mr.r.marinov@gmail.com).

I. Draganov is with the Faculty of Telecommunications, Technical University of Sofia, 8, Kliment Ohridski Blvd., 1756 Sofia, Bulgaria (e-mail: idraganov@tu-sofia.bg).

https://doi.org/10.47978/TUS.2022.72.01.003

occupying all available office spaces. The COVID-19 pandemic induced investment drop in commercial areas by at least 80% within 2020, compared to 2019 [9]. The actual exploited commercial space in the first half of 2020 decrease with 30% in contrast to the second half of 2019 [9]. The total amount of commercial areas is thought to be 400 000 m^2, but the newly built areas in 2020 cover 38 600 m^2 – 57% less than 2019 [9]. All these tendencies, undoubtfully, although indirectly, affect the real estate market as well. Real estate agencies need a plan for recovery after the COVID-19 pandemic, as stated in [10].

The main aim of the current study is to find the change of the average price of the 1-, 2-, and 3-room real estates from a set of representative neighborhoods in Sofia, Bulgaria, for the period 2019-2021. Statistical distribution of the prices over all investigated properties with approximations of the evolving trends over time by neighborhood, suitable for future predictions of the selling rates, and clustering of the neighborhoods by price category are the established models within this research. In Section II the methodology of the investigation is presented, followed by experimental results in Section III, and discussion in Section IV. Section V contains the conclusions.

II. ETL PROCESS

The ETL (Extract, Transform, Load) process is described below:

1. Extraction of Data:
   a. The Data has been manually extracted and stored in Excel files. The Data is taken on monthly bases since January 2019 till October 2021, 34 files in total.
   b. Data clean – simple C# tool was made for deleting empty columns and meaningless rows from all 34 Excel files (Fig. 1).

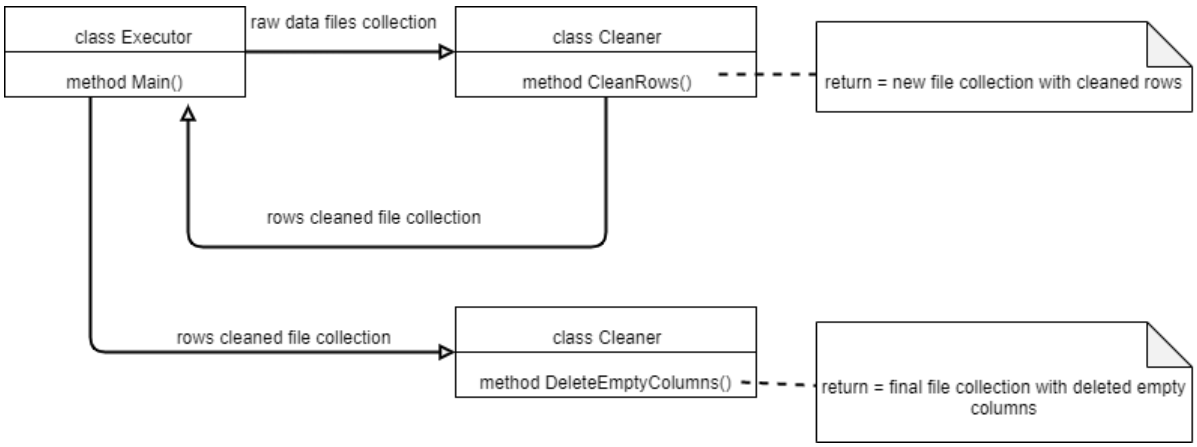

Fig. 1. Process of cleaning the data

2. Transformation of Data
   a. The Data from all Excel tables with initially cleaned data has been loaded into dedicated "staging" MS SQL Server database tables. Each of these "staging" tables has the following table: definition:

```
CREATE TABLE [dbo].[Sofia-apartments-20XX-XX](
   [District] [nvarchar](255) NULL,
   [AvaragePricePerOneBedroomFlat] [float] NULL,
   [AvarageOneBedroomFlatPricePerSquareMeter €/m2] [float]
NULL,
   [AvaragePricePerTwoBedroomFlat] [float] NULL,
   [AvarageTwoBedroomFlatPricePerSquareMeter €/m2] [float]
NULL,
   [AvaragePricePerThreeBedroomFlat] [float] NULL,
   [AvarageThreeBedroomFlatPricePerSquareMeter €/m2] [float]
NULL,
   [AvaragePricePerSquareMeter €/m2] [float] NULL
   ) ON [PRIMARY]
```

   b. Transformation by monthly time series

The data from the staging tables is populated into new monthly times series tables with the following definition:

```
CREATE TABLE [dbo].[Sofia-XXX-bedroom-avarage](
   [District] [nvarchar](100) NULL,
   [2019-01] [float] NULL,
   [2019-02] [float] NULL,
   [2019-03] [float] NULL,
   ...
) ON [PRIMARY]
```

   c. Data aggregation by year quarters

New tables are not needed, once we have the data in the monthly times series tables we can transform it "on the fly" using View database objects, following below is a typical definition:

```
CREATE VIEW [v].[Sofia-all-bedroom-avarage-Quarters]
as
(
SELECT [District]
      ,ROUND((([2019-01] + [2019-02] + [2019-03]) / 3), 0) as
[2019-Q1]
      ...
      ,ROUND((([2021-07] + [2021-08] + [2021-09]) / 3), 0) as
[2021-Q3]
      ,[2021-10] as [2021-Q4]
  FROM [RealEstate].[dbo].[Sofia-XXX-bedroom-avarage]
)
```

3. Load of Data into Datamart

In our case study the Datamart is Excel table in which we will store the final data and use it for our further analysis.

III. EXPERIMENTAL RESULTS

The raw input data is derived from [11]. The variation of the price for an apartment per square meter in Sofia, Bulgaria, divided in one, two and three bedroom types and for all types of apartments, considering the neighborhood, is presented by families of curves on a quarter basis (by 3 months each for a

calendar year) in Fig. 2-5. The period of study includes a year before the pandemic, that is 2019, the whole 2020, when on March 8th the first proven case of this disease is discovered, and further on through 2021.

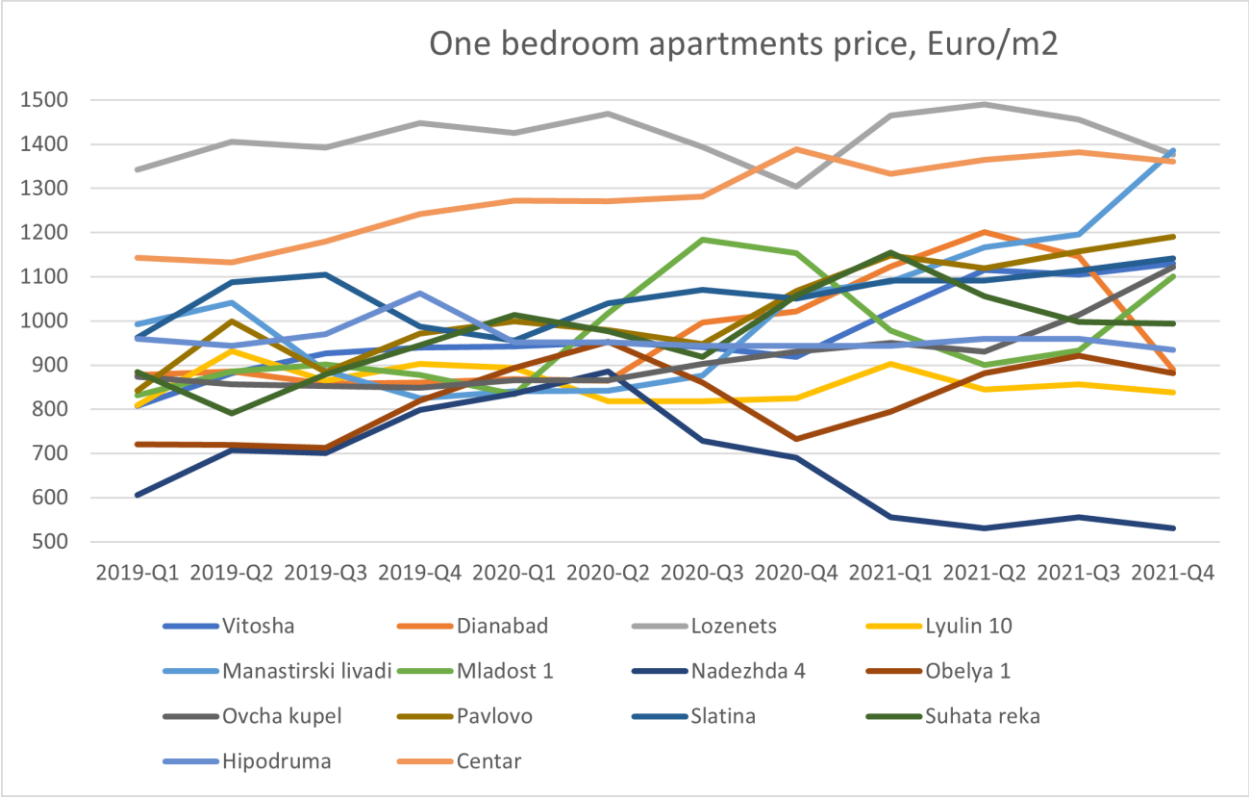

Fig. 2. One bedroom apartments price change from 2019 to 2021

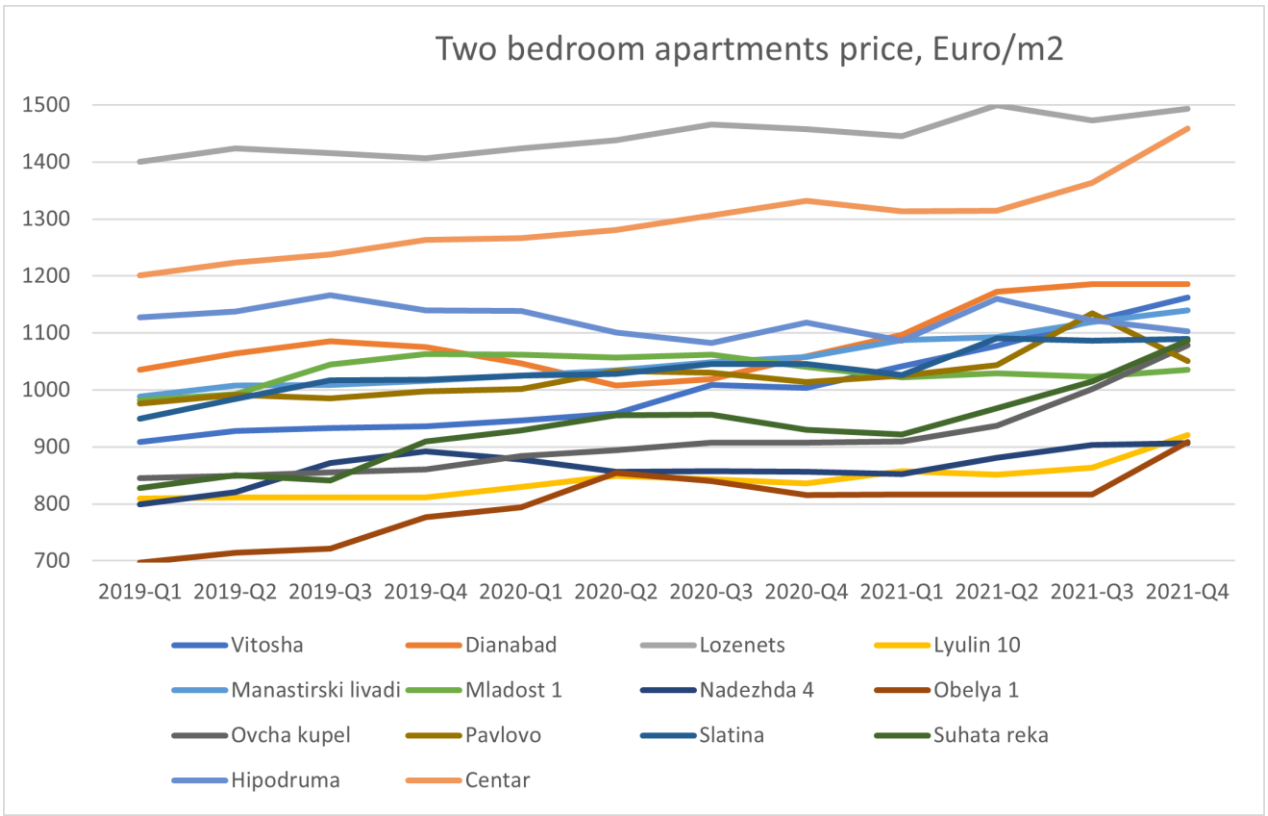

Fig. 3. Two bedroom apartments price change from 2019 to 2021

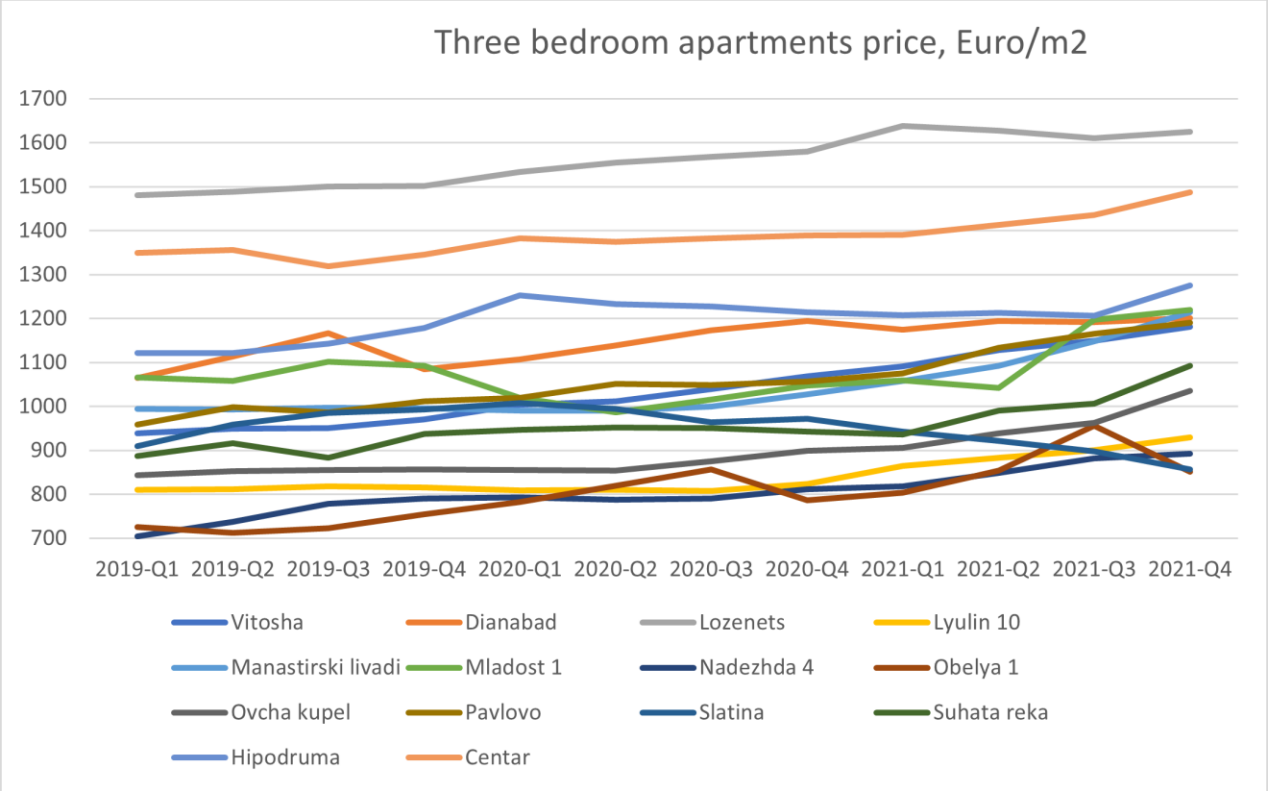

Fig. 4. Three bedroom apartments price change from 2019 to 2021

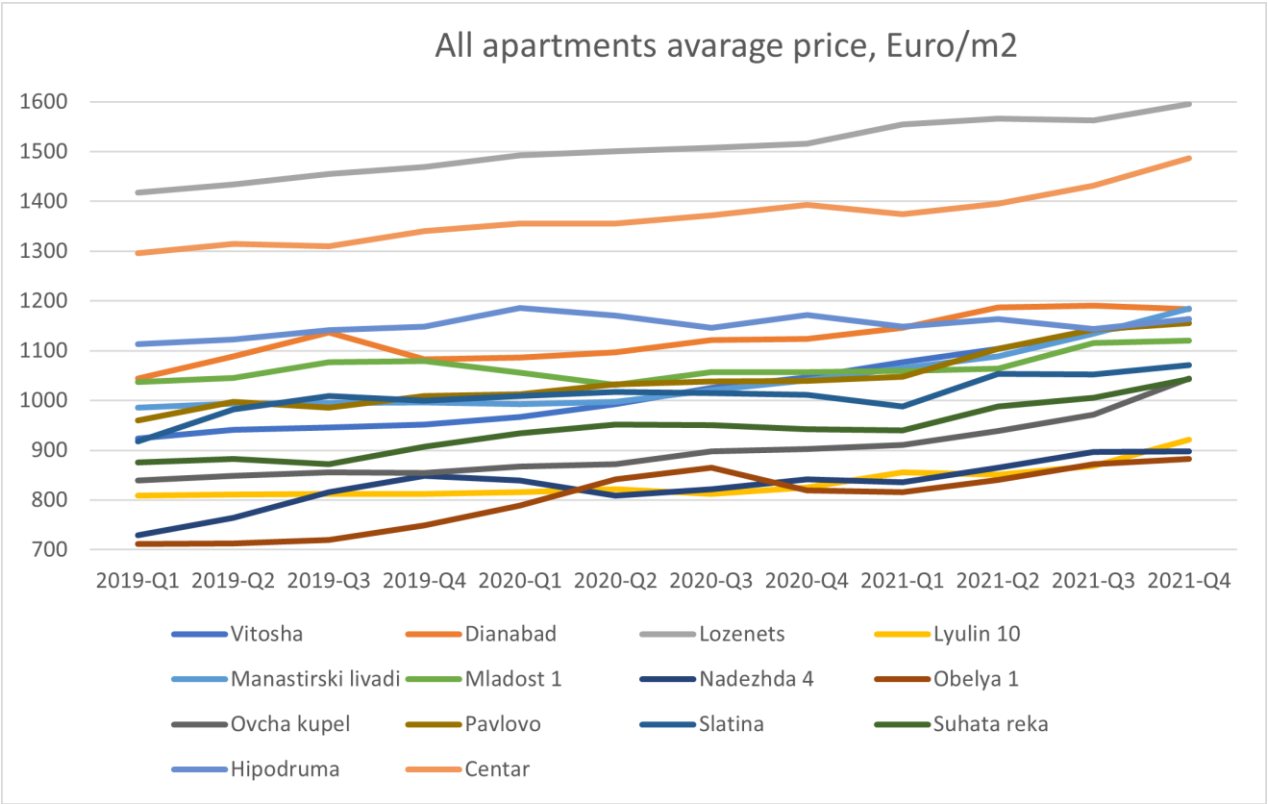

Fig. 5. All apartments price change from 2019 to 2021

First and second order statistical moments (mean – Av., median – Med., and variance – Var.) for the price over all types of apartments by neighborhood are given in Table I. Taking the average price of all types of apartments on a quarter basis for each of the studied years as an input, it becomes possible to build their discrete distributions (Fig. 6-8, in green) and to introduce continuous approximations for them (shown in red). All computations are accomplished at the use of the XLSTAT software [12].

TABLE I
MEAN, MEDIAN AND VARIANCE OF THE REAL ESTATE PRICE

Clusters	2019			2020			2021		
	Av.	Med.	Var.	Av.	Med.	Var.	Av.	Med.	Var.
Vitosha	940	944	149	1008	1009	908	1136	1139	908
Dianabad	1088	1086	1454	1107	1109	12	1187	1187	12
Lozenets	1444	1445	525	1504	1505	333	1575	1566	333
Lyulin 10	811	812	2	819	819	1333	880	868	1333
Manastirski livadi	993	995	26	1013	1009	2258	1136	1134	2258
Mladost 1	1060	1061	468	1050	1057	976	1100	1116	976
Nadezhda 4	790	790	2851	828	830	352	887	897	352
Obelya 1	724	717	302	829	830	481	865	872	481
Ovcha kupel	849	852	54	885	885	2896	985	971	2896
Pavlovo	988	992	437	1031	1035	702	1134	1142	702
Slatina	977	991	1671	1013	1013	114	1059	1053	114
Suhata reka	885	880	246	945	946	793	1012	1005	793
Hipodruma	1131	1132	259	1169	1171	127	1157	1163	127
Centar	1315	1313	337	1369	1364	2143	1438	1432	2143
Nadezhda 4	940	944	149	1008	1009	908	1136	1139	908

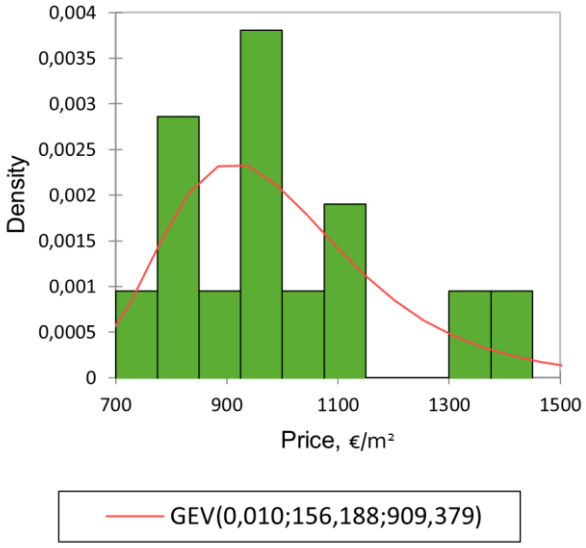

Fig. 6. All apartments price distribution for 2019

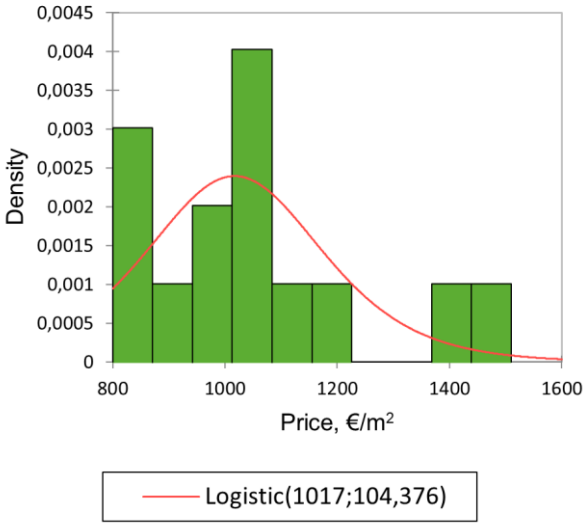

Fig. 7. All apartments price distribution for 2020

The significance level is set to 5% [13] in finding the most relevant distribution among the types, listed in Table II, using automatic computation, according to the maximum likelihood method. The convergence of all cases is 0.00001.

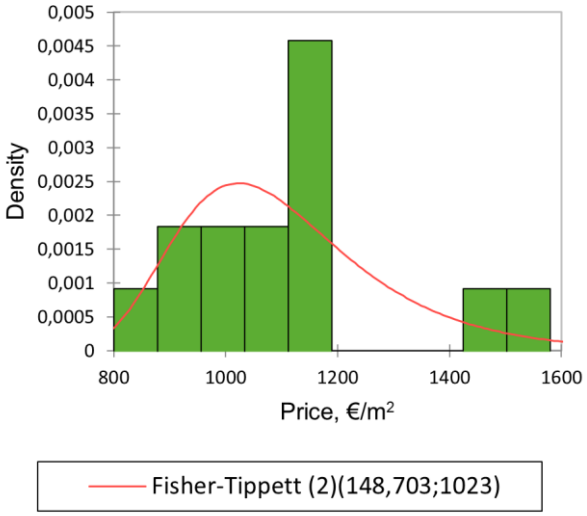

Fig. 8. All apartments price distribution for 2021

TABLE II
P-VALUES FOR ALL TRIED DISTRIBUTIONS OVER ALL APARTMENTS

Distribution	2019	2020	2021
Beta4	0,622	-	-
Chi-square	0,053	0,085	0,084
Erlang	0,960	0,795	0,840
Exponential	0,001	0,000	0,000
Fisher-Tippett (1)	<0,0001	<0,0001	<0,0001
Fisher-Tippett (2)	0,998	0,887	**0,911**
Gamma (1)	<0,0001	<0,0001	<0,0001
Gamma (2)	0,939	0,756	0,678
GEV	**0,998**	0,891	0,886
Gumbel	<0,0001	<0,0001	<0,0001
Log-normal	0,973	0,832	0,756
Logistic	0,979	**0,928**	0,895
Normal	0,827	0,600	0,536
Normal (Standard)	<0,0001	<0,0001	<0,0001
Student	<0,0001	<0,0001	<0,0001
Weibull (1)	<0,0001	<0,0001	<0,0001
Weibull (2)	0,753	0,501	0,346

The estimated parameters of the Generalized Extreme Value (GEV) distribution (Fig. 5) are: $k = 0.010 \pm 0.237$, $\beta = 156.188 \pm 0.485$, and $\mu = 909.379 \pm 0.456$. The Logistic distribution (Fig. 7) has the following parameters: $\mu = 1017.176$ and $s = 104.376$. Approximating to Fischer-Tippett distribution (Fig. 7) gives $\beta = 148.703 \pm 41.809$ and $\mu = 1022.939 \pm 31.643$. Log-likelihood (LL) statistics, with the Bayesian Information Criterion (BIC) and the Akaike Information Criterion (AIC) for all three distributions are given in Table III.

TABLE III
LOG-LIKELIHOOD STATISTICS

Parameter	GEV	Logistic	Fischer-Tippett
LL	-92,467	-93,277	-92,282
BIC	192,851	191,832	189,843
AIC	190,934	190,554	188,565

Statistics derived from the actual input data and through the parameters of the approximated distributions are compared in Table IV. Both the Skewness and the Kurtosis parameters are found based on the Pearson criterion.

TABLE IV
ACTUAL AND PREDICTED DATA STATISTICS

Distribution	GEV		Logistic		Fischer-Tippett	
Statistic	Data	Predicted	Data	Predicted	Data	Predicted
Mean	999,536	1001,107	1040,482	1017,176	1110,595	1108,773
Variance	40130,5	41216,684	39973,09	35840,66	40367,866	36373,634
Skewness	0,712	0,001	0,918	0,000	0,831	1,140
Kurtosisi	-0,385	207691276,8	-0,078	1,200	-0,046	2,400

The Kolmogorov-Smirnov test yielded the parameter values, shown in Table V. All of them confirm the proposed hypotheses for distribution types in the three cases as shown in Fig. 6-8.

TABLE V
KOLMOGOROV-SMIRNOV TEST PARAMETERS

Distribution	GEV	Logistic	Fischer-Tippett
D	0,095	0,136	0,140
p-value	0,998	0,928	0,911
Alpha	0,050	0,050	0,050

Further, the analysis continues with a linear regression approximation of the trends, observed in Fig. 5 (all apartments by neighborhood), leading to predicting function of the type: $y = mx + c$, (1)

where x is the current quarter in time, y – predicted price, m – coefficient of proportion, c – free scalar. All values of m and c with their precision after the approximation are given in Table VI. The MyCurveFit [14] software is applied during the calculations.

TABLE VI
LINEAR REGRESSION PARAMETERS BY NEIGHBORHOOD

District	m	Δm	c	Δc
Vitosha	22,51	1,40	876,57	10,29
Dianabad	11,33	1,98	1050,26	14,54
Lozenetz	15,44	0,68	1405,64	4,99
Lyulin 10	7,88	1,63	783,23	11,96
Manastirski livadi	16,15	2,48	936,17	18,25
Mladost 1	4,86	1,90	1034,91	13,96
Nadezhda 4	11,72	2,14	754,15	15,77
Obelya 1	16,04	2,31	697,18	16,97
Ovcha kupel	15,22	2,15	801,09	15,84
Pavlovo	15,91	1,75	940,09	12,85
Slatina	8,99	2,00	951,92	14,71
Suhata reka	13,76	1,54	851,59	11,37
Hipodruma	2,92	1,57	1132,55	11,58
Centar	14,15	1,56	1276,77	11,48

The R^2 (R^2 measure), aR^2 (Adjusted R^2 value), P (P-value), SE (Standard Error), and F (F-statistic) parameters reveal the level of accurate prediction by all derived linear models (Table VII).

TABLE VII
ACCURACY OF THE LINEAR REGRESSION MODELS

District	R^2	aR^2	P	SE	F
Vitosha	0.9628	0.9591	1.77E-8	16.72	259.14
Dianabad	0.766	0.7435	1,89E-4	23.63	32.89
Lozenets	0.9811	0.9792	6.0E-10	8.11	518.72
Lyulin 10	0.7020	0.6722	6.68E-4	19.44	23.56
Manstirski livadi	0.8094	0.7903	6.76E-5	29.65	42.46
Mladost 1	0.3962	0.3358	2.83E-2	22.69	6.56
Nadezhda 4	0.7494	0.7244	2.73E-4	25.63	29.91
Obelya 1	0.8288	0.8117	3.91E-5	27.58	48.42
Ovcha kupel	0.8332	0.8165	3.43E-5	25.75	49.94
Pavlovo	0.8925	0.8818	3.70E-6	20.88	83.05
Slatina	0.6689	0.6358	1.15E-3	23.91	20.20
Suhata reka	0.8880	0.8768	4.55E-6	18.47	79.31
Hipodruma	0.2556	0.1812	9.36E-2	18.82	3.43
Centar	0.8917	0.8809	3.84E-6	18.65	82.35

K-means clustering is performed with K-means++ initialization, followed by 10 re-runs with a limitation of 300 steps, using the Orange v.3.28 machine learning application [15]. Initially, the range of possible number of clusters is set from 2 to 8, and the optimal number of clusters for each type of apartment over the years is given in Table VIII, where the Silhouette score is applied as target parameter.

TABLE VIII
SILHOUETTE SCORES FOR FINDING THE OPTIMAL NUMBER OF CLUSTERS BY TYPE OF APARTMENT

Clus-ters	One Room Apartments			Two Room Apartments			Three Room Apartments		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
2	**0.474**	**0.462**	0.178	**0.308**	**0.411**	**0.395**	**0.255**	**0.304**	**0.373**
3	0.238	0.149	**0.201**	0.168	0.183	0.224	0.175	0.165	0.209
4	0.089	0.100	0.125	0.130	0.133	0.117	0.116	0.123	0.162
5	0.053	0.088	0.082	0.047	0.059	0.071	0.085	0.095	0.071
6	0.035	0.024	0.054	0.041	0.023	0.041	0.050	0.041	0.033
7	0.016	0.019	0.031	0.022	0.019	0.037	0.034	0.032	0.018
8	0.013	0.012	0.019	0.017	0.013	0.013	0.015	0.010	0.014

The clustering by a price category for all apartments, represented by the C_1 class as low and C_2 – as high, over the full set of studied neighborhoods, is shown in Fig. 9 for 2019, Fig. 10 – for 2020, and Fig. 11 – for 2021.

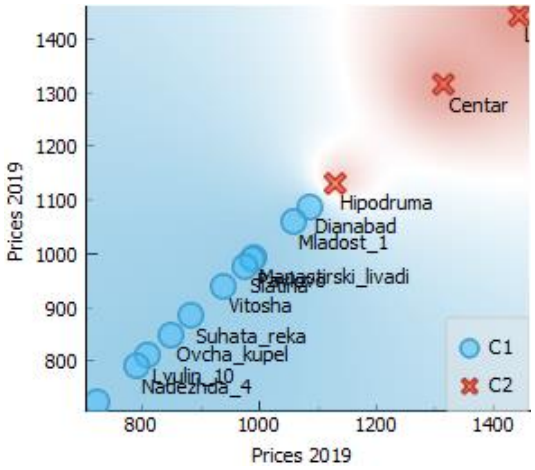

Fig. 9. All apartments clusters for 2019

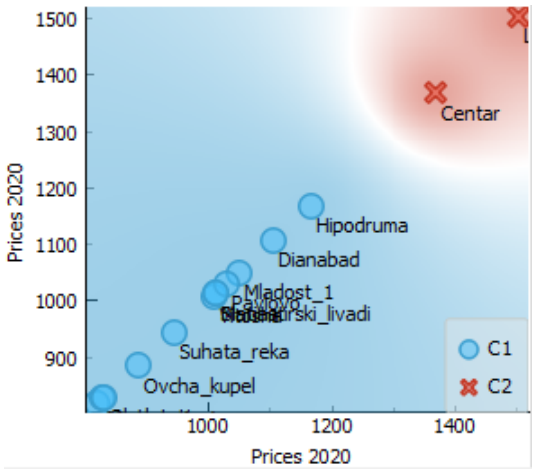

Fig. 10. All apartments clusters for 2020

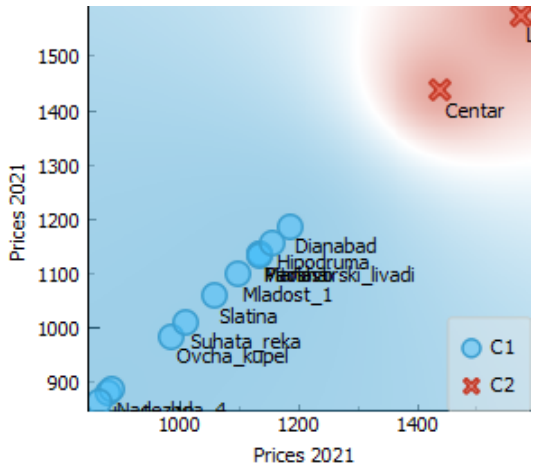

Fig. 11. All apartments clusters for 2021

The distribution of the one-, two-, three-, and all bed apartments by clusters with the associated Silhouette scores in the period 2019-2021 for each neighbourhood are given in Tables IX-XII.

TABLE IX
ONE BEDROOM APARTMENTS CLUSTERING

Year	2019	2019	2020	2020	2021	2021
Neighborhood	Cluster	Silhouette	Cluster	Silhouette	Cluster	Silhouette
Vitosha	C2	0.653034	C1	0.643392	C3	0.555858
Dianabad	C2	0.650149	C1	0.64365	C3	0.55712
Lozenets	C2	0.65747	C2	0.652921	C1	0.604256
Lyulin_10	C2	0.651202	C1	0.656258	C3	0.558929
Manastirski_livadi	C2	0.658962	C1	0.650268	C1	0.505603
Mladost_1	C2	0.650762	C1	0.590547	C3	0.599975
Nadezhda_4	C2	0.604496	C1	0.655685	C2	0.5
Obelya_1	C2	0.619066	C1	0.655326	C3	0.565759
Ovcha_kupel	C2	0.647954	C1	0.652318	C3	0.593214
Pavlovo	C2	0.657624	C1	0.621239	C3	0.515061
Slatina	C2	0.665779	C1	0.603213	C3	0.545612
Suhata_reka	C1	0.5	C1	0.624255	C3	0.576438
Hipodruma	C2	0.66305	C1	0.64085	C3	0.605582
Centar	C2	0.666702	C2	0.629763	C1	0.5912

TABLE X
TWO BEDROOM APARTMENTS CLUSTERING

Year	2019	2019	2020	2020	2021	2021
Neighborhood	Cluster	Silhouette	Cluster	Silhouette	Cluster	Silhouette
Vitosha	C2	0.611078	C1	0.63424	C1	0.598498
Dianabad	C2	0.521269	C1	0.613386	C1	0.552978
Lozenets	C1	0.619658	C2	0.641584	C2	0.644232
Lyulin_10	C2	0.632232	C1	0.650231	C1	0.64675
Manastirski_livadi	C2	0.571032	C1	0.60909	C1	0.592652
Mladost_1	C2	0.560167	C1	0.601177	C1	0.629804
Nadezhda_4	C2	0.629133	C1	0.650137	C1	0.646855
Obelya_1	C2	0.632111	C1	0.64998	C1	0.64566
Ovcha_kupel	C2	0.628327	C1	0.648391	C1	0.639999
Pavlovo	C2	0.582601	C1	0.619735	C1	0.617104
Slatina	C2	0.5797	C1	0.612118	C1	0.612915
Suhata_reka	C2	0.627656	C1	0.642721	C1	0.637032
Hipodruma	C1	0.526817	C1	0.559073	C1	0.587355
Centar	C1	0.591923	C2	0.59634	C2	0.612658

TABLE XI
THREE BEDROOM APARTMENTS CLUSTERING

Year	2019	2019	2020	2020	2021	2021
Neighborhood	Cluster	Silhouette	Cluster	Silhouette	Cluster	Silhouette
Vitosha	C2	0.576681	C2	0.575711	C1	0.595216
Dianabad	C1	0.512759	C1	0.486535	C1	0.564987
Lozenets	C1	0.606053	C1	0.614961	C2	0.637324
Lyulin_10	C2	0.618158	C2	0.631112	C1	0.644998
Manastirski_livadi	C2	0.552185	C2	0.589903	C1	0.599496
Mladost_1	C1	0.490133	C2	0.582951	C1	0.59882
Nadezhda_4	C2	0.623329	C2	0.631726	C1	0.645303
Obelya_1	C2	0.623921	C2	0.631158	C1	0.645317
Ovcha_kupel	C2	0.611669	C2	0.626048	C1	0.641103
Pavlovo	C2	0.572061	C2	0.568705	C1	0.593281
Slatina	C2	0.572061	C2	0.597283	C1	0.644705
Suhata_reka	C2	0.596345	C2	0.609938	C1	0.635165
Hipodruma	C1	0.536606	C1	0.548379	C1	0.539632
Centar	C1	0.603679	C1	0.6063	C2	0.589142

TABLE XII
ALL APARTMENTS CLUSTERING

Year	2019	2019	2020	2020	2021	2021
Neighborhood	Cluster	Silhouette	Cluster	Silhouette	Cluster	Silhouette
Vitosha	C1	0.6073	C1	0.625915	C1	0.601712
Dianabad	C1	0.516753	C1	0.577686	C1	0.570544
Lozenets	C2	0.6202	C2	0.645374	C2	0.644721
Lyulin_10	C1	0.631492	C1	0.649232	C1	0.648138
Manastirski_livadi	C1	0.584393	C1	0.624294	C1	0.601712
Mladost_1	C1	0.540387	C1	0.609862	C1	0.617535
Nadezhda_4	C1	0.632523	C1	0.64928	C1	0.648221
Obelya_1	C1	0.632453	C1	0.649281	C1	0.647827
Ovcha_kupel	C1	0.627931	C1	0.64757	C1	0.643855
Pavlovo	C1	0.586974	C1	0.61783	C1	0.602714
Slatina	C1	0.59233	C1	0.624294	C1	0.630542
Suhata_reka	C1	0.622105	C1	0.640829	C1	0.640262
Hipodruma	C2	0.486913	C1	0.525932	C1	0.590228
Centar	C2	0.607198	C2	0.613198	C2	0.611812

IV. DISCUSSION

At a first glance, the variation of prices per m^2 for 1-bedroom apartments within the researched period, is the most dynamic (Fig. 2), compared to the trends for 2- and 3-bedroom apartments (Fig. 3 and 4). From 2019 to the end of 2020 there are 2 distinctive groupings for all types of apartments - in low and high price category. In 2021 there seems to appear a third group, only for the 1-bedroom apartments, with especially lower prices for the Nadezhda 4 neighborhood. All these initial observations are confirmed by the clustering results - Fig. 9-11 and Tables IX-XII, supported by the Silhouette scores over the scatterings, obtained from the K-Means algorithm. The high dynamics in 1-bedroom apartments' prices, which seems to have a narrow dynamic range among neighborhoods for the first quarter in 2020, followed by smooth expansion in the second quarter of the same year and then rapid growth for the third and within the last 3 months of 2020 could be caused by several factors, that need to be investigated in the future. Two- and three-bedroom apartments' prices in virtually all neighborhoods keep steady, but not steep, increase during the whole period 2019-2021 (Fig. 3 and 4). The average price for all real estates, no matter of the living area size, follows that tendency as well (Fig. 5).

The linear regression approximation over all kinds of apartments for the whole studied time interval (Table VI) clearly proves that for all neighborhoods there is stable ascent in prices ($m > 0$). Much rapid increase is registered for the Vitosha neighborhood ($m = 22.51$), followed by Manstirski livadi ($m = 16.15$), and with least change in the price, but rising, are Mladost 1 ($m = 4.86$) and Hipodruma ($m = 2.92$). The difference in ascent rate of the price could be related to several factors: the rate of new buildings being built, which depends not only on the local investment interest, but also on the already present distribution of older buildings, the geographical location of the neighborhood in relation to key locations in the capital, e.g. the center, business zones, key transportation centers and others, the global level of development of the infrastructure, and on the global investments being made in that region for opening new job positions, as well as other factors. All of them need further research. The applicability of the derived linear models is supported by the evaluating accuracy measures from Table VII, e.g. with R^2 going above 0.7 with the exception of 3 of the neighborhoods (Mladost 1, Slatina, and Hipodruma). The trends to them could possibly be recomputed with higher order approximating curves in the future.

In 2021, without a strict lockdown due to the COVID-19 pandemic, there is even wider expansion of the prices among neighborhoods for 1-bedroom apartments. Early on, from Q1 there is increase in prices for most of the regions, which is being preserved up until the end of October. Four exceptions are most noticeable with their decrease in Fig. 2 (Lozenetz, Dianabad, Suhata reka and Nadezhda 4). More stable and compact in terms of deviation among neighborhoods in price, compared to 2020, seems the set of trends for both 2- and 3-bedroom apartments (Fig. 3 and 4).

Regardless of the type of real estate as number of rooms, but strictly following the price range, some significant differences could be observed between 2019, 2020, and 2021. In 2019, the cumulative price distribution, following most closely the GEV function (Fig. 6), demonstrate that prior the COVID-19 pandemic, there is smooth transition in the offerings between low-priced real estates (700-800 €/m^2), the mid-priced ones (900-1100 €/m^2), which seems to be dominating in share. The high-priced ones form a small portion at the upper bound around 1300-1500 €/m^2. In 2020, low-priced apartments (800-900 €/m^2) rise considerably as a share (Fig. 7, where the Logistic distribution fits the best the discrete values). The mid-range ones rise even higher with a share above 0.004 for the most demanded real estates of 1000 €/m^2. The high-priced apartments retained their share almost unchanged. This could be partly due to their limited number as offerings and the limited demand for them in general. In 2021 there is this sudden drop in the share of low-priced apartments, possibly by the fact that considerable amount of them is already being bought in the previous year during the high demand, but preserving and even increasing the share of the mid-priced ones to a level of almost 0.0045 (Fig. 8). There is also this offset of the peak for it to a levels, reaching 1200 €/m^2. The high-priced segment is again almost unchanged. The prediction accuracy of the so derived distribution models is evaluated through the parameters, shown in Table VI.

Following the general change in price and overall demand for particular real estate type, considering the realities of the COVID-19 pandemic, the following recommendations to brokerage companies could be suggested:

– Refining the price ranges for the various categories of apartments in the public offerings, announced mainly on web-sites and also in print publications, considering the latest price distribution from 2021 - more equally spaced and narrower price slots could be introduced up to the top of the mid-range of 1200 €/m^2; the high-price range could also be divided to at least 2 sub-intervals;

– More intense advertising of real estates that mark withhold for longer periods without any demand from customers in a more frequent campaigns, both electronically and through print editions; here the cheapest and some of the most expensive properties could be presented in a different way, using various announcement means;

– Search for potential clients, including non-typical ones, such as foreign citizens, attracted by new business opportunities in the country, for properties, which indicate definite drop in price, as observed for some of the neighborhoods, including those with less maintained infrastructure, where additional initiatives, involving new investments, could be undertaken.

V. Conclusions

In this paper, analysis is presented over the price evolution of real estates in 14 neighborhoods in Sofia, Bulgaria, for the period 2019-2021. There is obvious increase of the market share of real estates from both the low-price and mid-price range from 2019 to 2020, especially tangible for the first group. Then in 2021, there is a significant drop of the market share of low-priced properties. And in the same time ever increasing is the relative number of the mid-range in price apartments, for which the most frequent value demonstrate a shift to a higher level in the order of 1.2 times. There is no significant change of the share of high-priced properties over the part of the other 2 categories, from 2019 to 2021. All observed tendencies should be taken into account by all real estate brokerage companies while establishing their marketing strategies for wider and more successful coverage of the market.

References

[1] Y. Georgieva, “Study of the Characteristics of the Residential Real Estate Market in Sofia”, *Management and Sustainable Development*, vol. 58, no. 3, pp. 5-9, 2016.
[2] D. Stefanov, “Trends in Residential Real Estates Market in Sofia, Bulgaria”, *Management and Education*, vol. XIV, no. 1, pp. 72-79, 2018.
[3] N. Gilina, “Attitudes of Institutional Changes to the Real Estate Market in Bulgaria”, in *Construction Entrepreneurship and Real Property*, Varna, Bulgaria: University of Economics – Varna, 2016, pp. 158-164.
[4] K. Valchev, “Comparative Analysis of the Quality Features of the Luxury, Urban Properties Announced in Sofia, London, Paris and Madrid”, in *Construction Entrepreneurship and Real Property*, Varna, Bulgaria: University of Economics – Varna, 2017, pp. 272-280.
[5] I. Kamenova, “Outsourcing Industry, Construction of Office Buildings, and the Office Market in Bulgaria - Trends and Development”, in *Construction Entrepreneurship and Real Property*, Varna, Bulgaria: University of Economics – Varna, 2019, pp. 142-153.
[6] K. Valchev, “Impact of Human Capital and Socio-Cultural Environment on the Real Estate Market High Class”, *Burgas Free University Annual*, vol. XXXIV, pp. 162-180, 2016.
[7] Y. Stoencheva, “Some Aspects in the Acquisition of Residential Real Estate in Primary and Secondary Real Estate Market In Bulgaria”, *Real Estate Property & Business*, vol. III, no. 2, pp. 108-113, 2019.
[8] C. Iliev, “Trends in Office Real Estate Market in Bulgaria”, *Izvestiya. Journal of Varna university of Economics*, vol. 60, no. 3, pp. 318-334, 2016.
[9] B. Atanasov, “The impact of the COVID-19 Pandemic on the Use of Commercial Areas”, *Real Estate Property & Business*, vol. V, no. 3, pp. 183-188, 2021.
[10] E. Duneva, “Real Estate Agencies in Sofia after COVID-19. Business Improvement Plan”, *Real Estate Property & Business*, vol. V, no. 1, pp. 47-58, 2021.
[11] Imot.bg – Site No. 1 for Real Estates, https://www.imot.bg/pcgi/imot.cgi
[12] XLSTAT (2007). Statistical Software for Excel, https://www.xlstat.com
[13] J. Kim and I. Choi, “Choosing the Level of Significance: A Decision-theoretic Approach”, *Abacus*, vol. 57, no. 1, pp. 27-71, 2021, https://doi.org/10.1111/abac.12172
[14] MyCurveFit, Online Curve Fitting, https://mycurvefit.com/
[15] Orange, https://orangedatamining.com/