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## EVALUATION OF REAL ESTATE MARKET VALUE IN UKRAINE USING WEB-SCRAPING

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**Summary.** Market value is one of the most important kind of information for every type of business – for startups on the planning stage, as well as for already grown business. It allows to make more accurate revenue predictions at financial planning stage and therefore investment decisions. In some cases, identification of market value can be a trivial task, when, for example, we deal with open organized information, but mostly, estimation of this parameter is very complex task that can be time consuming and requires the involvement of experts in various areas. It becomes even more difficult while trying to estimate the value of illiquid assets such as assets on real estate markets. The objective of the paper is the estimation the real estate market value using the approach of extracting and structuring data from web-sources and available data by web scraping based on Python programming language. Web crawler is more advanced software, it is the artificial intelligence that can navigate the web sites, follow the search links and extract data using specific rules. As the data source, ria.ua web site is chosen. The total market value, according to information represented on ria.ua is approximately \$ 10,9 billion. The evaluation shows the concentration of market mostly in Kiev, except business property, country houses, hotels, land and warehouses. At the same time, Kiev is the leader in the sphere of office complexes, parking places, recreation. The leaders of apartment sales are Kiev and Odesa regions, other regions are significantly behind Kiev and Odesa. On the basis of carried out analysis, we can come to the conclusion that the price is highly correlated with the type of real estate and moderately correlated with region of sale.

**Key words:** market value, real estate market, web-scraping, value of real estate, Big Data.

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## ОЦІНЮВАННЯ ВАРТОСТІ РИНКУ НЕРУХОМОСТІ В УКРАЇНІ З ВИКОРИСТАННЯМ WEB-SCRAPING

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**Резюме.** Ринкова цінність є одним з важливіших видів інформації для кожного виду бізнесу – як для стартапів на етапі планування, так і для вже вирошеного бізнесу. Це дозволяє робити точніші прогнози доходів на етапі фінансового планування, а отже, інвестиційні рішення. У деяких випадках ідентифікація ринкової вартості може бути тривіальним завданням, коли ми маємо справу з відкритою організованою інформацією, але здебільшого, оцінювання цього параметра є надскладним завданням, яке займає багато часу і вимагає залучення експертів різних сфер. Певні обмеження виникають, якщо оцінюється вартість неліквідних активів, таких, як активи на ринках нерухомості. Розглянуто підхід до оцінювання ринкової вартості ринку нерухомості або його капіталізації за допомогою підходу агрегування та структурування даних із веб-джерел на основі веб-скрейпінгу із використанням мови програмування Python. Webcrawler – це вдосконалене програмне забезпечення, штучний інтелект, що переміщується по веб-сайтах, переходить по посиланнях для пошуку та вилучення даних за допомогою конкретних правил. Загальна ринкова вартість згідно з інформацією, представленою на ria.ua, приблизно дорівнює на певну дату 10,9 мільярда доларів. Оцінювання показує концентрацію ринку в основному у Києві, за винятком

комерційної нерухомості, заміських будинків, готелів, земель та складських приміщень. Водночас Київ є безперечним лідером у сфері офісних комплексів, паркування, рекреаційного відпочинку. Лідерами із продажу квартир є Київ та Одеська область, інші регіони значно відстають від цих міст. На основі аналізу зроблено висновок, що ціна сильно корелює з типом нерухомості та меншою мірою корелює з регіоном продажу.

**Ключові слова:** ринкова вартість, ринок нерухомості, веб-стрейпінг, ціна нерухомості, Великі дані.

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**Introduction.** Market value is the total value of all products and/or services that are sold on a certain market within a certain period. Estimation of this parameter is one of the most important steps for every startup on a stage of financial planning and it can be very useful for already grown up business because it allows to make more accurate revenue forecasts and output capacity. However, estimation of this value requires a lot of data about specific market, usage of various analytical tools and expert knowledge. Traditional market value estimation approach depends on statistical data, gathered by government and third-party companies, but even if that data exists, we can't be sure about its quality because the data can be not full, which can lead to wrong decisions. There is also difficult to aggregate data using traditional approaches like polls. The internet, on contrary, contains a lot of data that can be very useful for valuation, but the main obstacle is that they can be unstructured and placed on various sources that makes them difficult for analysis. This problem can be bypassed using web scraping techniques.

Web scraping is an automated process of creation the structured representation of data from various web sources using special software – web scraping bots. There are two types of such bots – web crawler and web spider. Web spider is a software designed to extract data from specific source, for example from exact web site using CSS or XPATH selectors. Web crawler is more advanced software, it is an artificial intelligence that can navigate through web sites, follow links to search and extract data using specific rules. The web scraping approach has specific advantages and drawbacks. The advantages are:

- if data exist on web sources – they can be extracted and structured;
- data extraction process, using web scraping, is tremendously faster than manual data collection or traditional data gathering approaches such as polls;
- the data can be updated after a certain time using the same software, which allows to track changes on the market in real time;
- web scraping allows to lower dependencies on statistical data, that are collected by government or third-party companies.

On the other hand, the following disadvantages should be noted:

- writing of web spiders requires a lot of special knowledge and skills in programming field;
- it can be difficult to realize web scraping projects from technical point of view;
- some web resources use different protection systems to prevent data from scraping;
- only available data can be extracted freely, anyone cannot scrape data without data owner's permission under user agreement.

**Review of the latest research and literature.** The problems of using Intermate data and methodology of Big Data analysis. João Manuel Azevedo Santos used real estate market data scraping and analysis for financial investments [1]. Maciej Beresewicz presented the usage of Internet data sources for real estate market in Poland [2]. EzgiCandas, Seda BagdatliKalkan and Tahsin Yomralioglu tried to determine which parameters can be used as evaluation factors

for housing prices [3]. Robert Hu and Emil Sjögren searched the best fitted analysis method for prediction the prices for the apartment in Stockholm based on its characteristics [4].

The basis of using Web scraping with Python is described in papers [5–15].

**The objective of the paper** is to evaluate the Ukrainian real estate market or its capitalization using web scraping technique for collecting data. To achieve this goal, we realized the following tasks:

- the web spider for data extraction is designed. As a source of data, ria.ua web site is chosen, that is one of the biggest platforms of Ukrainian real estate market. The spider should not only collect all necessary data, but also not abuse web source server with too many requests. The spider is written using Python programming language and Scrapy framework;

- collected data should be cleaned and structured before further analysis, for this task Pandas library is used;

- to calculate the value of Ukraine real estate market the collected data must be analyzed, for this purpose Pandas library and data visualization tools - matplotlib, sea born and folium are used.

While their processing we assumed that:

- Only data from ria.ua are used for market value estimation because one unique real estate object can be represented on various web sites, and to remove such duplicated observations special algorithms are to be used.

- The market value is be calculated for a certain date – when data have been collected. To calculate market value for different periods – additional data must be collected.

**Data extraction and preprocessing.** Project GitHub is posted on repository: <https://github.com/rndmBot/Market-value>.

The data are collected from Ria.ua – one of the biggest Ukraine advertisement platforms. Web spider is designed using Scrapy – asynchronous web scraping framework for Python programming language. The web spider code can be found on GitHub repository, the spider extracts data from web source and stores it in csv format. Sample of web spider's output is represented in table 1.

**Table 1.** Web spider output (5 first observations of 261855)

Parse	Parse2	Price_usd	Parse3
/ru/realty-perevireno-prodaja-kvartira-kiev-so...	Solomensky Str. Yerevan 1 room Kiev	71 970 \$	1 room 57 m2
/ru/realty-perevireno-prodaja-kvartira-kiev-so...	SolomenskyMashinobudivnavulitsya 1 room Kiev	68 000 \$	1 room 68 m2
/ru/realty-perevireno-prodaja-dom-vinnitsa-yak...	Yakushintsyst. Bogdan Khmelniysky 134 m square	53 000 \$	134 m2 7 hectare
/ru/realty-perevireno-prodaja-kvartira-vinnitsa...	Sverdlovsk massif st. Matrosa Koshki 1	36 500 \$	1 room 36 m2
/ru/realty-perevireno-prodaja-kvartira-vinnitsa...	Strizhavka Alei street 1 room. Vinnitsa	16 582 \$	1 room 40.24 m2

The raw data contains 261855 observations, the data is not appropriate for analysis in that representation and must be preprocessed. Preprocessing script can be found on Git Hub repository. The preprocessing steps are as follows:

- Null values removal: «price\_usd» contains null values, these observations must be dropped, because they do not bring any information. Number of observations after null values removal – 260053.

- «Parse» column preprocessing – the next information can be extracted from this column:

- a) offer type – sell, long term rent (lt\_rent), short term rent (st\_rent);
  - b) real estate type – apartments, house, PSN, office, land, part of house, recreational, room, commercial area, services, country house, hotel, industrial, warehouse, business, office complex, garage, parking space;
    - extracting city name from «parse2» column;
    - «Region» column creation – the region of the city have been extracted using Geopylibrary Nominatim geocoder;
    - for convenience of usage, city and region column values have been transliterated from Ukrainian to English using TranslitUA library;
    - «parse3» column preprocessing – the next information extracted from this column: number of rooms for apartments, living area, area of a land;
    - «price\_usd» column preprocessing – the column contains values in Ukrainian hryvnias that must be converted to US dollars and «\$» signs that must be cleaned;
    - calculation of price for square meter and 1/100 of hectare.
- The preprocessed data represented in table 2.

**Table 2.** Preprocessed data (first 5 observations of 258984)

	Price_usd	Offer_type	Type	City	Region	Rooms	Area	Land – area	Price_sqm	Price_hndr
0	71970.0	sell	apartments	Kyiv	Kyiv	1.0	57.0	NaN	1262.63	NaN
1	68000.0	sell	apartments	Kyiv	Kyiv	1.0	68.0	NaN	1000.00	NaN
2	53000.0	sell	house	Vinnitsa	Vinnytska	NaN	134.0	7.0	395.52	7571.43
3	36500.0	sell	apartments	Vinnitsa	Vinnytska	1.0	36.0	NaN	1013.89	NaN
4	16582.0	sell	apartments	Vinnitsa	Vinnytska	1.0	40.0	NaN	414.55	NaN

Data analysis and market value calculation script can be found on GitHub repository: <https://github.com/rndmBot/Market-value>

The «offer\_type» column contains three types of offers – sell, long term rent and short term rent, to calculate Ukraine’s real estate market only «sell» offer have been used. After offer selection the data contains 221576 observations. The next step – is the calculation of basic statistics of the Dataset.

**Table 3.** Basic statistics of the Dataset

	Price_usd	Type	City	Region	Rooms	Area	Land_area	Price_sqm	Price_hndr
Count	221576	221576	221576	221576	159239	201114	42833	201114	42831
Unique	nan	18	463	25	nan	nan	nan	nan	nan
Top	nan	apartments	Odesa	Odeska	nan	nan	nan	nan	nan
Freq	nan	159245	64239	68129	nan	nan	nan	nan	nan
Mean	89064	NaN	NaN	NaN	2	10557	50171	inf	inf
Std	700380	NaN	NaN	NaN	1	3161373	10376237	nan	nan
Min	0	NaN	NaN	NaN	1	0	0	0	0
25%	26000	NaN	NaN	NaN	1	45	6	510	938
50%	43000	NaN	NaN	NaN	2	63	10	725	3688
75%	78000	NaN	NaN	NaN	3	90	16	1034	14833
max	278000000	NaN	NaN	NaN	65	1000000000	2147480000	inf	inf

The observations according to table 3 are:

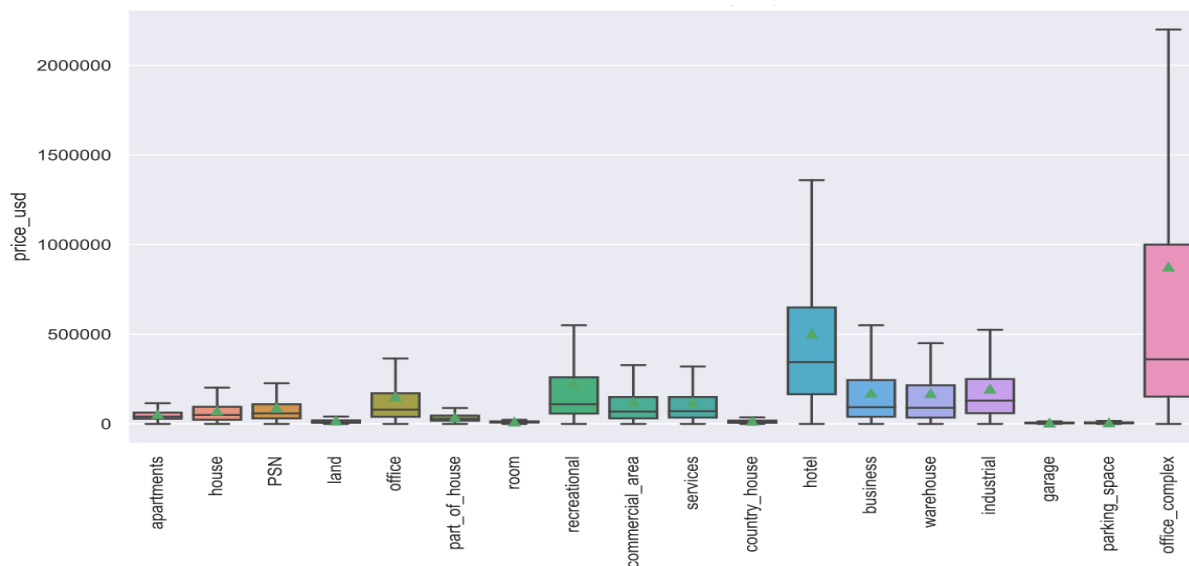
- «price\_usd» column contains zero values that must be dropped. Also, this column contains huge outliers that must be removed before further analysis.

- «rooms» column, according to maximum value 65, contains huge outliers.
- «area» and «land\_area» columns contain huge outliers.
- «price\_sqm» and «price\_hdnr» columns contain infinite numbers that must be replaced with nan values.

Outliers must be removed before the market value calculation, because they can lead to wrong estimations. Outliers elimination algorithm (source code can be found on GitHub repository) contains:

- splitting dataset according to region and loop through each region;
- for each region splitting data by type of real estate;
- for each type of real estate calculation IQR for each column, that contains numeric values;
- detecting and dropping lower and upper outliers by  $1.5 \cdot \text{IQR}$ .

After outlier elimination the dataset contains 190214 observations. Figures 1, 2 show the dependence of prices on the type of property and the region of sale. The price is highly correlated with type of real estate and moderately correlated with region of sale.



**Figure 1.** Real estate price according to the type

The next step is the calculation of market value of real estate market in Ukraine or its capitalization. According to the data the next parameters are calculated:

- total Ukraine real estate market value.
- Ukraine real estate market value according to region of sale.
- Ukraine real estate market value according to type of real estate.
- Ukraine's real estate market value according to type and region of sale of real estate.

The total Ukraine's market value is calculated as the sum of all real estate property prices. The total market value, according to information represented on ria.ua is approximately \$ 10993508874. Total real estate stock in the world is \$ 168.5 trillion with 22% in North America, 23% in Europe, 25% in China and Hong Kong, 19% Asia Pacific. Although Ukrainian real estate market doesn't include all assets, but is represented only for sales, it is small and constitutes scanty fraction. The share of Ukrainian real estate market in transaction volume on the global market is 1%.

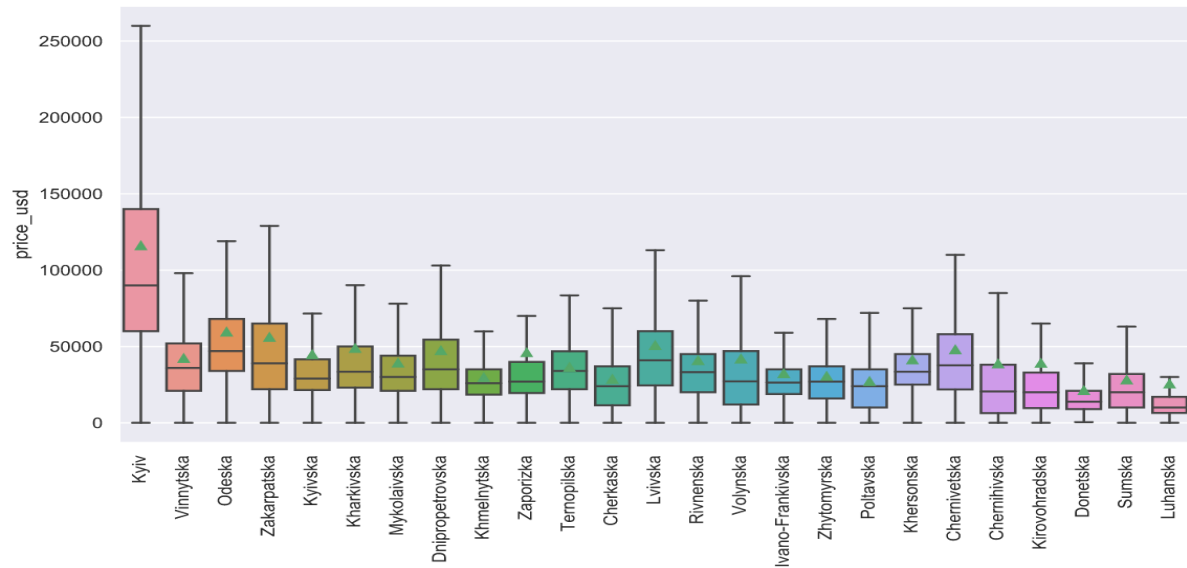


Figure 2. Real estate price according to the region

Market value according to region of sale is represented in Table 4 and in Figure 3.

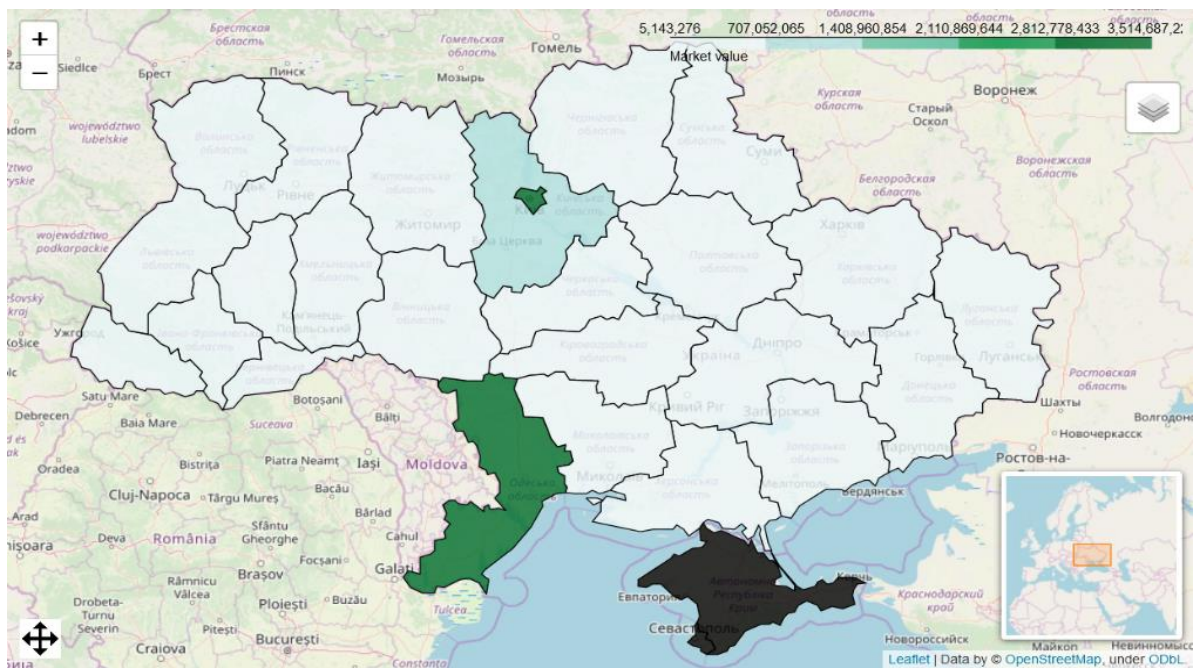


Figure 3. Ukraine's real estate market value according to the region of sale

**Table 4.** Ukraine's real estate market value by the region of sale (in US dollars)

Region	Market value	Share
Odeska	3514687222	0,320
Kyiv	3237764652	0,295
Kyivska	849892140	0,077
Vinnytska	525050631	0,048
Kharkivska	411549088	0,037
Dnipropetrovska	346582824	0,032
Ternopilska	283081737	0,026
Lvivska	238389625	0,022
Ivano-Frankivska	197759496	0,018
Khersonska	184199466	0,017
Khmelnyska	168931559	0,015
Zaporizka	159758391	0,015
Zakarpatska	158961998	0,014
Mykolaivska	155573201	0,014
Rivnenska	114585308	0,010
Zhytomyrska	105198504	0,010
Poltavska	80588291	0,007
Chernivetska	66216818	0,006
Donetska	50946614	0,005
Cherkaska	45812840	0,004
Volynska	32199824	0,003
Chernihivska	29162115	0,003
Sumska	16343166	0,001
Kirovohradska	15130088	0,001
Luhanska	5143276	0,000

Real estate market value according to property type is represented in Table 5. It is not surprising that apartments occupy such a large share – 68% of the market capitalization. It is more than 4 times higher than the volume of house market, 20 times higher than all commercial and business property.

**Table 5.** Ukraine's real estate market value according to the property type

Type	Market value	Share
Apartments	7427087721	0,676
House	1837629678	0,167
PSN	285753690	0,026
Office_complex	202191643	0,018
Office	182266631	0,017
Land	168793809	0,015
Commercial_area	157836481	0,014
Business	131940366	0,012
Hotel	128642819	0,012
Industrial	120153625	0,011
Recreational	119683453	0,011
Part_of_house	73013462	0,007
Warehouse	60646115	0,006
Services	55663273	0,005
Country_house	23737203	0,002
Room	11665724	0,001
Garage	4374183	0,000
Parking_space	2428998	0,000

Analyzing the property type real estate by the regions (Table 6) it could be seen that Kiev is the leader not in all spheres.

**Table 6.** Ukraine's real estate market value by the region of sale and the type of property (in thousands of US dollars)

	Apartments	Business	Commercial	Country house	Garage	Hotel	House	Industrial	Land	Office	Office complex	Part of house	Recreational	Room	Services	Warehouse
Kyiv	0,36	0,07	0,25	0,05	0,25	0,20	0,07	0,07	0,10	0,49	0,64	0,04	0,27	0,08	0,30	0,04
Vynnytska	0,03	0,07	0,04	0,09	0,07	0,03	0,09	0,07	0,16	0,02	0,01	0,14	0,04	0,19	0,04	0,17
Odeska	0,35	0,51	0,07	0,23	0,03	0,46	0,30	0,04	0,17	0,11	0,23	0,07	0,09	0,31	0,36	0,32
Zak-ska	0,01	0,03	0,04	0,02	0,01	0,04	0,03	0,07	0,05	0,00	0,01	0,03	0,04	na	0,02	0,02
Kyivska	0,05	0,02	0,02	0,16	0,04	0,03	0,20	0,13	0,13	0,02	0,01	0,18	0,08	0,02	0,03	0,08
Khar-ska	0,03	0,03	0,25	0,04	0,04	0,01	0,03	0,06	0,01	0,21	0,02	0,03	0,02	0,12	0,02	0,02
Mykol-ska	0,01	0,02	0,02	0,02	0,01	0,01	0,02	0,04	0,01	0,01	0,01	0,02	0,03	0,03	0,01	0,01
Dnip-ska	0,03	0,03	0,08	0,06	0,03	0,02	0,04	0,08	0,05	0,05	0,02	0,02	0,05	0,01	0,07	0,15
Khmel-ska	0,01	0,02	0,03	0,02	0,08	0,01	0,02	0,02	0,03	0,01	0,00	0,01	0,02	0,01	0,01	0,02
Zapo-ka	0,01	0,01	0,02	0,02	0,01	0,04	0,02	0,05	0,01	0,01	0,03	0,01	0,16	0,01	0,01	0,02
Tern-ska	0,03	0,01	0,03	0,06	0,19	0,00	0,03	0,02	0,05	0,01	0,00	0,09	0,01	0,07	0,01	0,01
Cher-ska	0,00	0,01	0,01	0,03	0,02	na	0,01	0,02	0,01	0,00	0,00	0,02	0,01	0,01	0,01	0,01
Lvivska	0,02	0,03	0,04	0,02	0,07	0,06	0,03	0,07	0,05	0,02	0,01	0,03	0,05	0,01	0,04	0,06
Rivn-ska	0,01	0,03	0,02	0,02	0,02	na	0,02	0,01	0,02	0,01	0,00	0,09	0,03	0,02	0,01	0,01
Volynska	0,00	0,01	0,00	0,00	0,00	0,00	0,01	0,04	0,01	0,00	0,01	0,01	0,00	0,00	0,01	0,00
Ivano-Frank-ska	0,02	0,02	0,04	0,01	0,09	0,06	0,01	0,01	0,04	0,01	0,00	0,03	0,02	0,00	0,01	0,02
Zhytska	0,01	0,01	0,00	0,04	0,01	0,00	0,01	0,03	0,02	0,01	na	0,08	0,00	0,07	0,01	0,02
Poltavska	0,01	0,00	0,00	0,04	0,01	0,01	0,01	0,03	0,03	0,00	na	0,01	0,00	0,01	0,01	0,00
Khers-ska	0,01	0,03	0,00	0,03	0,01	0,01	0,03	0,02	0,02	0,00	na	0,04	0,04	0,01	0,01	0,00
Chern-ska	0,00	0,02	0,00	0,01	0,01	0,01	0,01	0,02	0,01	0,01	na	0,03	0,01	0,00	0,02	0,01
Chernih-ska	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,08	0,00	0,00	0,00	0,01	0,01	0,01	0,00	0,00
Kirov-ska	0,00	0,00	0,00	0,00	0,00	na	0,00	0,00	0,00	0,02	na	0,01	0,00	na	0,00	0,00
Donetska	0,00	0,01	0,00	0,00	0,01	na	0,01	0,00	0,00	0,00	na	0,00	0,00	0,00	0,00	0,00
Sumska	0,00	0,01	0,01	0,00	0,00	na	0,00	0,00	0,00	0,00	na	0,00	0,01	0,00	0,01	0,01
Luhanska	0,00	0,00	0,00	0,00	0,00	na	0,00	0,00	0,00	0,00	0,01	0,00	0,00	na	0,00	0,00

Specifically, for business property, country houses, houses, land, industrial property, part of house, rooms and warehouses. At the same time, Kiev is preeminent leader in the sphere of office and office complex (49 and 64%), parking (43%), recreation (0,27%). The leaders of apartments are Kiev and Odesa regions (36 and 35%), other regions significantly lag from Kiev and Odesa. For business property the leader is Odesa (51%). For commercial property besides Kiev on the top is Kharkiv region (25%). On the market of country houses the leaders are Odesa region (23%), Kharkiv region (16%), Vynnytsia (9%). Hotel property are market assets for the most at Odesa (46%) and Kiev (20%), business – at Kiev (13%), Dnipropetrovsk (8%). The



leaders on warehouse market are Odesa (22%), Vinnytsia (17%), Dnipropetrovsk (15%), Kyiv (8%).

**Conclusions.** The investigation described in this paper indicates that using Web scraping for real estate market can be useful for estimation of market capitalization and its structure. The main focus in the paper is limited only to one data source and city, though it could be expanded to other sources, e. g. olx.ua. The evaluation shows the market concentration mostly in Kiev, except for business property, country houses, hotel property, land and warehouses.

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