

CLUSTER ANALYSIS OF REGIONAL MARKETS OF AUTOCLAVE AERATED CONCRETE IN UKRAINE BY PRICE LEVEL AND SUPPLY LEVEL INDICATORS

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Abstract. One of the key priorities of the construction industry is well-balanced provision of the country's regions with modern building and construction materials. That is why the research of the balance between supply and demand in the regional markets of Ukraine is extremely important. The object of this study is the aerated concrete market of Ukraine. The purpose of the work is to carry out a cluster analysis of regional aerated concrete markets of Ukraine in terms of price level and supply level. The article examines the situation in regional markets for aerated concrete as one of the leading wall materials, resulting in specifying regional trends in prices for this wall material, as well as proves the need for state regulation of its prices in a particular region in order to increase construction and reduce disparities in prices. The paper identifies the degree of monopoly of the aerated concrete market of Ukraine in the conditions of oligopoly. The author considers the location of aerated concrete enterprises in Ukraine and identifies the directions and scopes of distribution of their products based on such data as sales volume and regional sales structure of each manufacturer. The study analyzes the supply of aerated concrete in each region and evaluates the proportion of its distribution on the territory of Ukraine in accordance with such factors as the area of the region, its population and the size of regional GDP. As a result, it is found out that in some regions there are disparities between supply and demand. However, in most regions of Ukraine the aerated concrete market is balanced.

Keywords: price, aerated concrete, market, region, oligopoly, import, demand, supply, market balance, cluster, cluster analysis.

JEL classification: E30, L19, L22

Formulas: 3; **fig.:**0; **tabl.:**4; **bibl.:** 20

Introduction. At present, autoclaved aerated concrete (hereinafter-aerated concrete) is one of the most effective wall building materials in Ukraine. Thus, according to the All-Ukrainian Association of Autoclaved Aerated Concrete Producers, over the past 10 years aerated concrete has taken the largest share among structural wall materials in Ukraine, it increased from 8% in 2010 to 53% in 2020 (VAAG,2020). However, the development of the aerated concrete market in Ukraine, in our opinion, is constrained by the lack of state regulation of prices for this material, as a result of which aerated concrete is rapidly becoming more expensive, which, in turn, leads to a constant increase in construction costs. In this case, in order to regulate the pricing of aerated concrete one should first investigate the pricing process for this building material in Ukraine (Skrypnyk, O. 2018), including the supply and demand for it.

The market of wall building materials in Ukraine has a clear regional segmentation (Skrypnyk, O. 2018), which is primarily due to the high cost of transportation of aerated concrete from the production sites to other regions. Thus, according to our research the cost of delivery of aerated concrete in Ukraine from the production sites to other regions is on average 0.6-1.5 UAH / (m³ * km) taking into account the cost of returning the car to the factory (Corporation «HSM» 2020).

Therefore, the study of regional aerated concrete markets will not only identify the regional trends in prices for this material, but also the need for state regulation of its prices in a particular region, as well as possible ways and forms of such regulation. As for the goods structure of autoclaved aerated concrete in Ukraine, the predominant market share is occupied by aerated concrete blocks in the form of parallelepiped with a density of D400 and D500, meanwhile, several manufacturers (TOV “Dnepropetrovsk Plant of Construction Materials”, PJSC “Zhytomyr CSR”, TOV “Ternopilbud”) produce a density of only D500 (Zakharchenko, P 2020). It should be noted that the D400 and D500 density products can easily replace each other (i.e. they are interchangeable with a slight adjustment of the construction project) and therefore belong to one and not to different markets.

The first stage of the analysis of the aerated concrete market in Ukraine was conducted in our previous publication (Skrypnyk, O. 2018) and included an analysis of the market monopoly and geographical location of aerated concrete producers in Ukraine. The next steps are to identify aerated concrete supply in the regions of Ukraine, to evaluate the proportion of its distribution throughout the country, and to determine the dependence between the relative level of aerated concrete prices in the region and the relative supply in regional aerated concrete markets. This article is an attempt to solve the above-mentioned tasks.

Literature Review. Research of the aerated concrete market of Ukraine is conducted on regular basis by the All-Ukrainian Association of Autoclaved Aerated Concrete Producers (VAAG) (including the executive director O.V. Sirotin (Sirotin, O. 2017)), as well as the Department of Commodity Research and Commercial Activity in the Construction of KNUBA under the leadership of prof. Zakharchenko (Zakharchenko, P 2020). However, these studies focus on the production, export and import of aerated concrete, while the issues of national and regional supply and demand, as well as formation of regional prices for aerated concrete have not been studied yet.

The issues of cluster analysis in construction are revealed in the works of A.F. Goyko and L.V. Sorokin (Goiko, A. 2013), O.Yu. Belenkova (Bielienkova, O. 2019), I.S. Golovko-Marchenko (Golovko-Marchenko, I. 2015), etc., however, the condition of regional construction materials markets in Ukraine has not been considered in these works.

Aims. The purpose of the article is to conduct a cluster analysis of regional markets of autoclaved aerated concrete in Ukraine in terms of price level and supply level in order to determine the features of pricing in this market.

Methods. In the research, the following methods were used: the balance method and the method of proportion (distribution of aerated concrete between the regions of Ukraine), the rating method (distribution of regions of Ukraine in clusters by level of aerated concrete), and the matrix method (cluster analysis of regional markets of autoclaved aerated concrete of Ukraine by price and supply levels).

Results. As already mentioned, the first stage of the analysis of regional aerated concrete markets was our 2018 evaluation of aerated concrete supply of regional markets in Ukraine based on the data concerning production capacity and location of

domestic producers (Skrypnyk, O. 2018). Considering the dynamics of aerated concrete production in Ukraine, it should be noted that in 2019 there were significant changes in the structure of aerated concrete supply, as a number of manufacturers stopped production and sold only previously produced stocks (PE “Budtehnologiya-N”, TOV “TBK”, TOV “Silicatobeton” , TOV “Teplobud-Sivershchina”) (Zakharchenko, P 2020). Accordingly, the degree of monopoly of this market increased, and the Herfindahl-Hirschman indicator increased to 1952.55 points (which is typical for highly concentrated oligopolistic markets). Based on the data on the sales volume of aerated concrete in Ukraine by domestic manufacturers, we divided the aerated concrete supply by regions. At the same time, we proceeded from the fact that the aerated concrete supply of a certain manufacturer in the region is directly proportional to its sales volume in Ukraine and inversely proportional to the distance from the place of production to a particular region. It should be noted that in real practice, the aerated concrete supply cannot be identified with its sales volume; but it is the sales volume that reflects it most accurately. In contrast to production capacity (which may not be fully used) or production volume (which may be greater or less than the supply volume, since the manufacturer may display for sale products from the warehouse, produced earlier or vice versa – send part of the products manufactured this year to the warehouse, not to the market). As a source of information, we used data from aerated concrete domestic producers and distributors concerning the availability of aerated concrete of a particular brand in a particular region and the distance from the production site to the administrative center of a particular region.

The distribution of aerated concrete supply by regions of Ukraine was made on the grounds of two assumptions based on the results of a survey of commercial department workers of some enterprises of this industry:

- The sales volume of a particular manufacturer in a particular region is inversely proportional to the distance from the production site to the administrative center of the region;
- The sales volume of a particular manufacturer in the region, the administrative center of which is closest to the place of production is twice less than the sales volume in the region of production.

Based on this assumption we have compiled and solved systems of equations for each manufacturer:

$$\begin{cases} X_1 + X_2 + \dots + X_n = D & (1); \\ X_1 = X_2 * 2 & (2); \\ X_i = X_2 * S_2 / S_n & (3); \end{cases}$$

where: X_1 - is sales volume in the region of production; X_2 - is sales in the nearest region; n - is the number of regions in which the products of this manufacturer are delivered; X_i - is sales in any region, except for the first and second; S_2 - is distance from the place of production to the second region; S_i - is distance from the place of production to the i -th region; D - is the total volume of aerated concrete production of a certain manufacturer in 2019.

Further, similar equations were solved for foreign producers represented on the domestic market.

According to the SFS (State Fiscal Service of Ukraine 2020). in 2019, Ukraine imported 343.390 tons of aerated concrete (which at an average density of D500 (500 kg / m³) gives us 686.776 thousand m³), and exported almost 10 times less (37.122 tons, or 72.244 thousand m³). At the same time, since the volumes of aerated concrete exports are insignificant, and the volumes of exports of specific domestic producers are unknown, the export of aerated concrete from Ukraine will not be taken into account in our further calculations.

Aerated concrete is imported mainly from two countries: Belarus and Poland.

As for the import of aerated concrete from Belarus, it has decreased significantly in recent years because of the anti-dumping investigation initiated by VAAG. In fact, the only Belarusian manufacturer whose products are actually on sale in Ukraine in 2019-2020 was the group of companies "SLS Group" (TM "SLS"). Deliveries to Ukraine are made from Berezhivsky KBI and SZAT "QuartzMelProm" (Khotyslav, Brest region). The price of the Belarusian aerated concrete enables it to compete successfully with domestic product.

As for Polish aerated concrete producers, only Xella aerated concrete (TM Ytong), manufactured at the company's plant in Ostrolissa, is supplied to Ukraine on regular basis (Maximus Center 2020). This plant is located at a distance from the centers of the border regions of Ukraine, quite similar to the distance from Kiev to them (for example, 488 km to Lviv, 498 km to Lutsk), but the price of Polish aerated concrete significantly exceeds the price of domestic equivalents.

Imported aerated concrete is sold mainly in Western Ukraine (Volyn, Zakarpattia, Rivne, Khmelnytsky, Ivano-Frankivsk, Chernivtsi, Ternopil, Lviv regions) and Northern Ukraine (Kyiv, Chernihiv, Zhytomyr regions), where both Belarusian and Polish aerated concrete can also be found. We calculated that the import volume of Belarusian aerated concrete is 288.337 thousand m³ (which generally corresponds to the results of other experts (Zakharchenko, P 2020), and the import volume of Polish aerated concrete is 398.442 thousand m³. The specified import volume was distributed between the above-mentioned regions inversely proportional to the distance from these foreign producers.

As a result of the distribution of sales of aerated concrete by domestic producers and the import volume between the regions of Ukraine, we determined the total sales of aerated concrete of Ukraine in each region. Then all regions were put in descending order of the total supply of aerated concrete and divided by this indicator into 3 groups: regions with high supply of aerated concrete, regions with medium supply and regions with low supply of aerated concrete. We did this by dividing into 3 parts the interval between the aerated concrete supply volume in Chernihiv region (which is second in the rating) and the aerated concrete supply volume in the last ranked Luhansk region (we did not take into account the supply volume in Kyiv region, as it is extremely high). Thus, regions with a total supply of aerated concrete up to 112 thousand m³ were included into the group with low supply of aerated concrete; regions with a total supply of aerated concrete from 112 thousand m³ to 205

thousand m^3 were included into the group with a medium supply of aerated concrete, and regions with a total supply of aerated concrete over 205 thousand m^3 were included into the group with high supply of aerated concrete.

The results of these studies are shown in Table 1.

Analysis of the data in Table 1 showed that the distribution of aerated concrete supply on the territory of Ukraine is extremely uneven. For example, the supply of aerated concrete in Kyiv region (where it is the highest) is more than 10 times higher than the supply in Luhansk region (where it is the lowest). However, the obtained results cannot give the accurate data of the level of aerated concrete supply in the regions in itself, as all regions differ in demographic, economic and geographical features. Therefore, to clarify the results, we analyzed the proportion of the regional distribution of aerated concrete supply in Ukraine in accordance with the area of the region, its population and the size of regional GDP (according to the State Statistics Committee of Ukraine). The initial data and the results of these calculations are given in Table 2.

Based on the data in Table 2 the regions were divided for each indicator into 3 clusters. To do this, we determined the difference between the maximum and minimum values for each indicator and divided it into three ranges. As a result, according to Table 4 we have identified extremely large disparities in the distribution of aerated concrete supply by regions of Ukraine.

As a result per 1 million UAH regional GDP distribution of aerated concrete by region of Ukraine showed that the maximum value of this indicator (4.29 thousand m^3 / million UAH in Chernihiv region) is 18.3 times higher than the minimum (0.23 thousand m^3 / million UAH) in Donetsk region). According to this indicator, the regions of Ukraine were divided as follows: up to 1.58 thousand m^3 / million. UAH – low supply; from 1.58 thousand m^3 / million UAH up to 2.94 thousand m^3 / million UAH – medium supply; over 2.94 thousand m^3 / million UAH - high supply.

As for the indicators of aerated concrete supply in the region per one thousand people and aerated concrete supply in the region per one km^2 area, the disparities in the regional distribution of aerated concrete were even greater. Thus, for the indicator of aerated concrete supply in the region per one thousand people, the maximum value (301.6 thousand m^3 / thousand people recorded in the Chernihiv region) is 34.3 times higher than the minimum (8.76 thousand m^3 / thousand people) in the Luhansk region). According to this indicator, the regions of Ukraine were divided as follows: up to 106 thousand m^3 / thousand people – low supply; from 106 thousand m^3 / thousand people to 204 thousand m^3 / thousand people – medium supply; more than 204 thousand m^3 / thousand people – high supply.

Considering the supply of aerated concrete in the region per one km^2 , we determined that the highest value of this indicator (19.3 thousand m^3 / per one km^2 , was recorded in Kyiv region), 27.5 times higher than the minimum (0.7 thousand. m^3 / per one km^2 in Luhansk region).

Table 1. Distribution of aerated concrete supply by regions of Ukraine (thousand m³) *

| Region / Trademark (or manufacturer) | TOV “AEROK” thousand m ³ | TOV “Orientyr- Budelement” thousand m ³ | TOV “YUDK” thousand m ³ | TOV “Energy Product” thousand m ³ | TOV “Yupiter” thousand m ³ | TOV “Plant Kharkiv Building Materials” thousand m ³ | TOV “Zhytomyr CSR” thousand m ³ | TOV “Dnipropetrovs k Plant BM” thousand m ³ | TOV “Ternopilbud” thousand m ³ | Import, thousand m ³ | Total volume of supply, thousand m ³ (supply level) |
|--|---|---|---------------------------------------|--|---|--|---|---|---|------------------------------------|--|
| Kyiv | 205,088 | 268,218 | 13,333 | 15,893 | - | 8,943 | 3,626 | - | - | 44,673 | 559,774(high) |
| Chernihiv | 101,108 | 134,109 | 11,134 | - | - | 8,493 | - | - | - | 44,059 | 298,903(high) |
| Zhytomyr | 102,544 | 96,558 | 9,929 | - | - | - | 7,934 | - | - | 51,958 | 268,923(high) |
| Dnipropetrovsk. | 29,943 | - | 141,836 | 35,81 | - | 19,777 | - | 13,788 | - | - | 241,154(high) |
| Mykolaiv | 29,943 | - | 18,793 | 69,4 | 120,236 | - | - | 1,827 | - | - | 240,199(high) |
| Cherkasy | 73,216 | 86,5 | 21,559 | 22,763 | - | - | - | - | - | - | 204,038(medium) |
| Vinnitsia | 53,323 | 56,326 | 10,567 | - | 25,37 | - | 3,967 | - | - | 42,655 | 192,208(medium) |
| Kherson | | 28,297 | 18,297 | 138,8 | - | - | - | 1,779 | - | - | 187,173(medium) |
| Ternopil | 34,147 | 35,673 | - | 12,145 | 14,849 | - | - | - | 21,706 | 62,139 | 180,659(medium) |
| Rivne | 43,889 | 45,061 | - | - | - | - | 2,702 | - | 7,868 | 75,304 | 174,824(medium) |
| Odesa | 30,25 | 32,052 | 13,262 | 35,741 | 60,118 | - | - | - | - | - | 171,423(medium) |
| Volyn | 35,89 | 37,282 | - | - | - | - | - | - | - | 87,767 | 160,939(medium) |
| Zaporizhzhya | 26,046 | | 70,918 | 41,293 | | 14,435 | | 6,894 | | | 159,586(medium) |
| Khmelnitsky | 44,402 | 45,597 | - | - | - | - | 2,773 | - | 10,853 | 52,924 | 156,549(medium) |
| Kharkiv | 29,84 | 33,661 | 27,658 | - | - | 60,022 | - | 2,689 | - | - | 153,87(medium) |
| Lviv | 26,559 | 28,029 | - | - | - | - | - | - | 9,41 | 73,373 | 137,371(medium) |
| Sumy | 43,068 | 51,364 | 17,446 | - | - | 23,319 | - | - | - | - | 135,197(medium) |
| Poltava | 41,735 | - | 33,331 | 22,069 | - | 30,011 | - | 3,24 | - | - | 130,386(medium) |
| Chernivtsi | 28,2 | 29,638 | - | - | 14,428 | - | - | - | 7,174 | 46,692 | 126,132(medium) |
| Kirovograd | 47,375 | 51,096 | 24,396 | - | - | - | - | 2,372 | - | - | 125,239(medium) |
| Ivano-Frankivsk | 23,688 | 27,358 | - | - | - | - | - | - | 8,986 | 55,205 | 115,237(medium) |
| Zakarpattia | 17,74 | 19,178 | - | - | - | - | - | - | - | 50,027 | 86,945(low) |
| Donetsk ** | - | - | 24,821 | 19,085 | | | | 2,413 | | | 46,319 (low) |
| Luhansk ** | | | 18,722 | | | | | | | | 18,722 (low) |
| Total | 1068 | 1106 | 476 | 413 | 235 | 165 | 21 | 35 | 66 | 686,776 | 4271,776 |

* - compiled by the author based on VAAG and websites of aerated concrete manufacturers in Ukraine.

** - data from the temporarily occupied territories of Donetsk and Luhansk regions are missing

Table 2. Distribution of aerated concrete supply by regions of Ukraine

| Region/ Indicator | The population of the region as of 01.01.2020 (in thousands) | Area of the region, km ² | Regional GDP for 2019, UAH million | Supply of aerated concrete in the region per one thousand people, thousand m ³ / one thousand people | Supply of aerated concrete in the region per 1 km ² , thousand m ³ / 1 km ² | Supply of aerated concrete in the region per 1 million UAH regional GDP, thousand m ³ / 1 million UAH |
|-------------------|--|-------------------------------------|------------------------------------|---|--|--|
| Vinnitsia | 1 545 | 26 513 | 111498 | 124,40647 | 7,2495757 | 1,606589 |
| Volyn | 1 031 | 20 144 | 60448 | 156,0999 | 7,9894261 | 2,838419 |
| Dnepropetrovsk | 3 176 | 31 914 | 369468 | 75,930101 | 7,5563702 | 0,631244 |
| Donetsk ** | 4 131 | 26 517 | 192256 | 11,212539 | 1,7467662 | 0,234361 |
| Zhytomyr | 1 208 | 29 832 | 77110 | 222,61838 | 9,0145817 | 3,463281 |
| Zakarpattia | 1 253 | 12 777 | 52445 | 69,389465 | 6,8048055 | 1,684789 |
| Zaporizhia | 1 687 | 27 180 | 147076 | 94,59751 | 5,8714496 | 1,070077 |
| Ivano-Frankivsk | 1 368 | 13 900 | 78443 | 84,237573 | 8,2904317 | 1,384594 |
| Kyiv | 4748 | 28 970 | 198160 | 117,8968 | 19,322541 | 0,514952 |
| Kirovograd | 933 | 24 588 | 64436 | 134,23258 | 5,0935009 | 1,859922 |
| Luhansk** | 2 135 | 26 684 | 35206 | 8,7690867 | 0,7016189 | 0,514796 |
| Lviv | 2 512 | 21 833 | 177243 | 54,685908 | 6,2918976 | 0,761339 |
| Mykolayiv | 1 119 | 24 598 | 79916 | 214,65505 | 9,7649809 | 2,881729 |
| Odesa | 2 377 | 33 310 | 173241 | 72,117375 | 5,1462924 | 0,97201 |
| Poltava | 1 386 | 28 748 | 174147 | 94,073593 | 4,5354807 | 0,742034 |
| Rivne | 1 152 | 20 047 | 56842 | 151,75694 | 8,7207063 | 2,839901 |
| Sumy | 1 068 | 23 834 | 68489 | 126,58895 | 5,6724427 | 1,912787 |
| Ternopil | 1 038 | 13 823 | 49133 | 174,04528 | 13,069449 | 3,611923 |
| Kharkiv | 2 658 | 31 415 | 233321 | 57,889391 | 4,8979787 | 0,650373 |
| Kherson | 1 027 | 28 461 | 55161 | 182,25219 | 6,5764731 | 3,329944 |
| Khmelnitsky | 1 254 | 20 645 | 75646 | 124,83971 | 7,5829014 | 2,073642 |
| Cherkasy | 1 192 | 20 900 | 93315 | 171,17282 | 9,7625837 | 2,118751 |
| Chernivtsi | 901 | 8 097 | 33903 | 139,99112 | 15,577621 | 3,563581 |
| Chernihiv | 991 | 31 865 | 70624 | 301,61756 | 9,3802919 | 4,296766 |

** - data from the temporarily occupied territories of Donetsk and Luhansk oblasts are missing.

According to this indicator, the regions of Ukraine were divided as follows: 6.9 thousand m³ / 1 km² - low supply; from 6.9 thousand m³ / 1 km² to 13.11 thousand m³ / 1 km² - medium; more than 13.11 thousand m³ / 1 km² - high supply.

Summarizing the qualitative results of all four indicators of the level of aerated concrete supply in the regions of Ukraine (one absolute and three relative), we determined an integrated evaluation of supply in the regional aerated concrete markets of Ukraine (Table 3). At the same time, in controversial cases, the criterion for including the region into a particular group was the indicator of the total supply of aerated concrete in the region.

This table also provides data on the price level for aerated concrete in the region in order to determine the relationship between the aerated concrete supply level and the price level for aerated concrete in the region.

Based on the data in Table 3, it can be concluded that in most regions of Ukraine the aerated concrete market seems to be balanced (13 regions where aerated concrete supply is medium), in 8 regions it seems to be in short supply (areas with low aerated concrete supply) and only in 3 areas with a high supply of aerated concrete it is probably redundant. It should be noted that for a reliable analysis of the balance of regional markets for aerated concrete in Ukraine one should also evaluate, directly or

indirectly, the demand for aerated concrete in the regions and compare them with supply indicators (which will be the aim of our further research).

Next, we determined the relationship between the price level for aerated concrete in the region and its supply level in this region. In order to do this, we first divided the regions of Ukraine into 3 groups according to the price level for aerated concrete, rejecting the abnormally high price in Luhansk region and dividing the remaining interval into 3 segments (low price is up to 1523 UAH / m³, medium is from 1523 UAH / m³ to 1786 UAH / m³, high price is more than 1786 UAH / m³).

Table 3. Integral supply evaluation in the regional markets of aerated concrete in Ukraine

| Region/ Indicator | Relative level of aerated concrete supply in the region (according to Table 1) | Supply of aerated concrete in the region by UAH 1 million. regional GDP | Supply of aerated concrete in the region per one thousand people (according to Table 2) | Supply of aerated concrete in the region per 1 km ² (according to Table 2) | Integral evaluation of the aerated concrete supply in the region | Regional price of aerated concrete as of 01.12. 2019, UAH / m ³ (Inproekt LLC 2020) |
|----------------------|---|--|--|---|--|--|
| Vinnitsia | Medium | Medium | Medium | Medium | Medium | 1680 |
| Volyn | Medium | Medium | Medium | Medium | Medium | 1740 |
| Dnipropetrovsk | High | Low | Low | Medium | Medium | 1670 |
| Donetsk** | Low | Low | Low | Low | Low | 1775 |
| Zhytomyr | High | High | High | Medium | High | 1500 |
| Zakarpattia | Low | Medium | Low | Low | Low | 1795 |
| Zaporizhia | Medium | Low | Low | Low | Low | 1500 |
| Ivano-Frankivsk | Medium | Low | Low | Medium | Medium | 1260,25 |
| Kyiv | High | Low | Medium | High | Medium | 1460 |
| Kirovohrad | Medium | Medium | Medium | Low | Medium | 2030 |
| Luhansk** | Low | Low | Low | Low | Low | 2980 |
| Lviv | Medium | Low | Low | Low | Low | 1317 |
| Mykolaiv | High | Medium | High | Medium | High | 1740 |
| Odesa | Medium | Low | Low | Low | Low | 1610 |
| Poltava | Medium | Low | Low | Low | Low | 2020 |
| Rivne | Medium | Medium | Medium | Medium | Medium | 2050 |
| Sumy | Medium | Medium | Medium | Low | Medium | 1500 |
| Ternopil | Medium | High | Medium | Medium | Medium | 1680 |
| Kharkiv | Medium | Low | Low | Low | Low | 1550 |
| Kherson | Medium | High | Medium | Low | Medium | 1540 |
| Khmelnitsky | Medium | Medium | Medium | Medium | Medium | 1480 |
| Cherkasy | Medium | Medium | Medium | Medium | Medium | 1586 |
| Chernivtsi | Medium | High | Medium | High | Medium | 1560 |
| Chernihiv | High | High | High | Medium | High | 1600 |

** - data from the temporarily occupied territories of Donetsk and Luhansk oblasts are missing.

Then based on this distribution and the data of Table 3 we comprised a matrix showing the distribution of regions of Ukraine in clusters according to two criteria: the relative price level for aerated concrete and the relative level of its supply in the region (Table 4):

Table 4. Cluster analysis matrix of aerated concrete regional markets of Ukraine by indicators of the price level for aerated concrete and its supply in the region

| Relative price level for aerated concrete / Relative supply level for aerated concrete in the region | Low supply | Medium supply | High supply |
|--|--------------------------------|--|---------------------|
| High price | Luhansk, Zakarpattia, Poltava, | Rivne, Kirovohrad | |
| Medium price | Donetsk, Kharkiv, Odessa | Volyn, Ternopil, Cherkasy, Kherson, Vinnytsia, Dnipropetrovsk Chernivtsi | Mykolaiv, Chernihiv |
| Low price | Zaporizhia, Lviv | Ivano-Frankivsk, Khmelnytsky, Sumy, Kyiv | Zhytomyr |

Source: develop by author

Based on the matrix, we can draw several conclusions:

1. The price of aerated concrete in most regions is low or medium, which indicates rather efficient logistics of aerated concrete transportation from production sites to most regions of Ukraine.

2. There is a clear relationship between the relative supply level of aerated concrete and its relative price level in the majority of regional markets of aerated concrete. This is an example of Walras's model of market equilibrium, as domestic producers do not set prices for each region, therefore price determines supply in the regional aerated concrete markets, not the other way around (unlike Marshall model).

Thus, in three clusters the ratio between supply and price clearly corresponds to Walras's model of market equilibrium: at a low price for aerated concrete there is a high level of its supply (particularly in the Zhytomyr region); at the same time, the high price of aerated concrete has a low level of supply (in Luhansk, Zakarpattia and Poltava regions), and at an medium price there is a medium level of supply (in Volyn, Ternopil, Cherkasy, Kherson, Vinnytsia, Dnipropetrovsk and Chernivtsi regions). The situation in the clusters "medium price - high supply" (Mykolaiv and Chernihiv regions), "high price - medium supply" (Rivne and Kirovohrad regions), "medium price - low supply" (Donetsk, Kharkiv and Odesa regions), "low price - medium supply" (Ivano-Frankivsk, Khmelnytsky, Sumy, Kyiv regions) does not contradict Walras's concept. Only a single cluster "low price - low supply" (which includes Zaporizhia and Lviv regions) does not correspond to this concept, which requires additional study (the reason might be a low demand for aerated concrete in these regions).

Discussion. It should be noted that in order to complete the analysis of the condition of regional aerated concrete markets of Ukraine, it is necessary to evaluate, directly or indirectly, the indicators of demand for aerated concrete in the regions and compare them with supply indicators (which will be the purpose of our further research).

Conclusion. As a result of the research of the supply and price levels in the regional markets of aerated concrete in Ukraine, we have made the following conclusions:

1. There is an oligopoly in the aerated concrete market of Ukraine, and the degree of monopoly of this market has increased significantly in recent years. In fact, there is no single aerated concrete market in Ukraine, but there is a separate local

market in each region (however, most of them are represented by the same domestic and foreign manufacturers).

2. The sales volume of a particular manufacturer in the region is inversely proportional to the distance from the plant to the region, and the sales volume of a particular manufacturer in the nearest region is twice less than the sales volume in the region of production.

3. The aerated concrete supply in Ukraine is distributed very unevenly, both in absolute terms and in terms of the area of the region, its population, the area of regional GDP. This can lead to disparities in supply and demand in regional aerated concrete markets, which will require government regulation. However, the price for aerated concrete in most regions is low or medium, which indicates rather efficient logistics of the transportation of aerated concrete from production sites to most regions of Ukraine.

4. The relationship between the price level for aerated concrete and its supply level in the regions of Ukraine is generally consistent with the Walras's model with some exceptions that require additional research.

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