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## **METHODOLOGICAL APPROACH TO EVALUATION AND STRATIFICATION OF HEI OF UKRAINE BY LEVEL OF INNOVATIVE ACTIVITY**

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Modern universities, in order to meet the requirements of the time, must perform not only the classical functions (education, research, education), but also acquire new features - innovation and entrepreneurship. Innovative development is an integral part of meeting a wide range of national interests of the state. The driving force behind the development of modern universities is innovation, which will allow us to move to a new generation of models. For Ukraine, which is at the stage of radical, transformational transformations of the higher education system, this is especially important, as there is a chance to make a significant breakthrough in the direction of creating an attractive international and national arena in accordance with the best world standards and trends. All this justifies the relevance of thorough research of the world practice of evaluation of innovative HEI.

The purpose of the methodological approach to the assessment and stratification of HEI of Ukraine is to determine the level of innovative activity of HEI and the formation of homogeneous universities at this level. Scheme of methodologies shown in fig. 1.

*Stage 1.* The evaluation of national educational institutions was carried out according to the selected indicators in terms of each component for the period 2012-2013, 2014-2015 and 2018-2019:

for the first group of indicators, which characterizes the educational activity of HEI: index of quality of human resources of HEI, index of quality of training, number of submitted applications to HEI, number of those who joined HEI, ratio of contractors and state employees [1, 2];

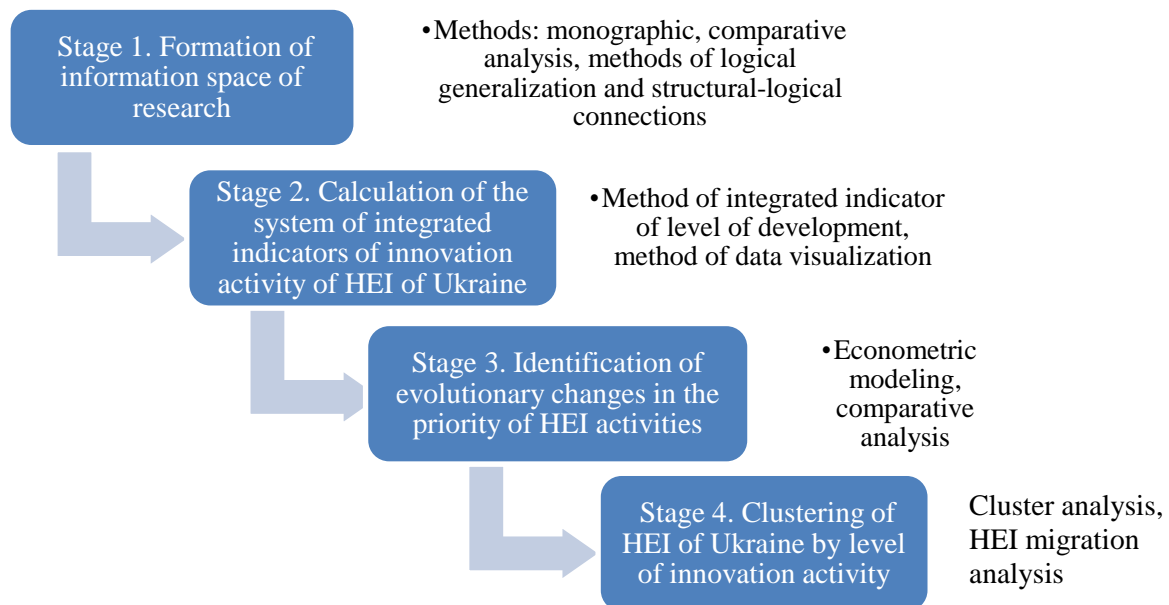


Figure 1. The scheme of stages of the methodical approach on definition of attractiveness of the national system of higher education

the second group of indicators, which characterizes scientific and technical activity: number of publications in Scopus, number of citations in Scopus, Worse index (h-index) [3, 4];

the third group of indicators, which characterizes the innovation activity: the number of patents, transparency rating or openness rating, rating of differences [3, 5, 1];

the fourth group of indicators that characterize international activity: index of international recognition, Impact Rank, Presence Rank, number of international students [6, 7 ].

Based on the results of the analysis, integrated indicators have been calculated, the value of which provides information on stratification and assessment of the level of innovation-active free economic zones before and after the enactment of the Law on Higher Education (2014), and to date.

*Stage 2.* To build an integrated indicator for the evaluation of innovatively active PHEI, it is proposed to use the method of taxonomy [8], which allows to reduce the set of features of the studied phenomenon to one synthetic feature. The algorithmic model for calculating the integrated indicator by the taxonomy method is presented in Fig. 2.

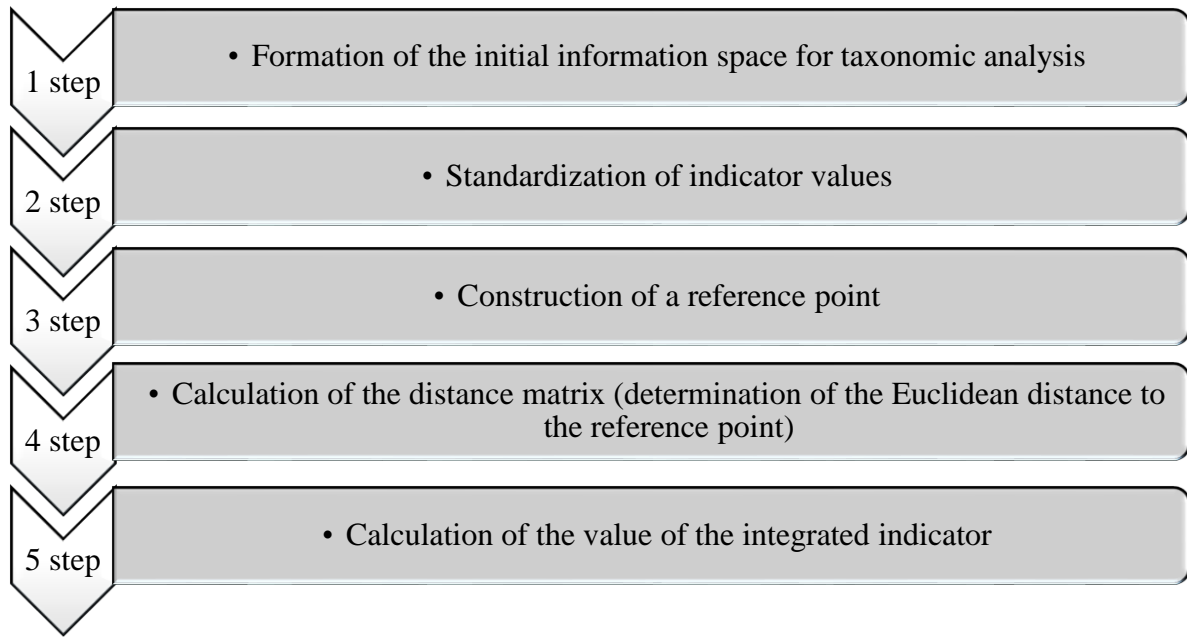


Figure 2. Algorithmic model for calculating the integrated indicator

Obtaining an integrated indicator of evaluation of innovatively active higher education institution is based on the formula (1):

$$Q_i = \frac{c_i}{\bar{c} + 3 \cdot S}, \quad c_i = \sqrt{\sum_{j=1}^m (z_{ij} - z_{je})^2 \cdot w_j}, \quad \bar{c} = \frac{1}{T} \sum_{i=1}^n c_i, \quad S = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (c_i - \bar{c})^2}, \quad (1)$$

where  $c_i$  – distance from the reference point;  $z_{je}$  – the reference value of the  $j$ -th indicator, which is formed as follows:  $z_{je} = \max_i z_{ij}$ , if the  $j$ -th sign is a stimulant,  $z_{je} = \min_i z_{ij}$ , if the  $j$ -th sign is a destimulator;  $w_j$  – weight value of the  $j$ -th indicator;  $j = [1 \div m]$ ;  $i = [1 \div n]$ ,  $z_{ij}$  – standardized value of the  $j$ -th indicator for the  $i$ -th object, obtained by the formula (2):

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{\sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_{ij} - \bar{x}_j)^2}}, \quad (2)$$

where  $x_{ij}$  – the value of the  $j$ -th indicator for the  $i$ -th object,  $\bar{x}_j$  – the average or reference value of the  $j$ -th indicator.

The integrated indicator obtained by this method is a normalized value, ie varies from 0 to 1, which allows to determine the tendency to change its value as for each component of institutional autonomy, and for all components in general.

Using this method, we obtain a system of integrated indicators containing the following set:

$$\{I_{general}, I_{osv}, I_{scien \text{ and } tech}, I_{innov}, I_{international}\} \quad (3)$$

where  $I_{general}$  – overall integrated indicator of HEI innovation activity;

$I_{osv}$  – local integrated indicator that characterizes educational activities;

$I_{scien \text{ and } tech}$  – local integrated indicator that characterizes scientific and technical

activities;

$I_{innov}$  – local integrated indicator that characterizes innovation activity;

$I_{international}$  – local integrated indicator that characterizes international activities.

In the table 1 shows the dynamics of the overall integrated indicator for assessing the innovative activity of higher education institutions in Ukraine.

Table 1.  
Dynamics of the general integrated indicators of an estimation of educational activity of HEI

HEI	2012-2013	2014-2015	2018-2019	The rate of change in 2019 compared to 2012,%
Berdyansk State Pedagogical University	0.473	0.422	0.496	<b>1.050</b>
Berdyansk University of Management and Business	0.428	0.468	0.503	<b>1.176</b>
Bila Tserkva National Agrarian University	0.415	0.492	0.515	<b>1.241</b>
Bukovynian State Medical University	0.399	0.413	0.468	<b>1.173</b>
Bukovynian State University of Finance and Economics	0.476	0.462	0.472	0.993
Open International University of Human Development "Ukraine"	0.471	0.433	0.379	0.804
Vinnitsia State Pedagogical University named after Mykhailo Kotsyubynsky	0.462	0.473	0.421	0.912
Vinnitsia National Agrarian University	0.451	0.425	0.440	0.975
Vinnitsia National Medical University named after E. Пирогова	0.482	0.436	0.479	0.992
....				
Kyiv State Academy of Water Transport named after Hetman Petro Konashevych-Sagaidachny	0.415	0.350	0.499	<b>1.204</b>
Kyiv Medical University UANM	0.570	0.401	0.607	<b>1.066</b>
Kyiv International University	0.557	0.409	0.413	0.741
Vadym Hetman Kyiv National University of Economics	0.599	0.423	0.525	0.876
Kyiv National Linguistic University	0.348	0.353	0.341	0.981
Kyiv National University of Trade and Economics	0.519	0.356	0.298	0.574
Kyiv National University of Construction and Architecture	0.454	0.402	0.493	<b>1.087</b>
Taras Shevchenko National University of Kyiv	0.695	0.728	0.644	0.927
Kyiv National University of Culture and Arts	0.481	0.374	0.535	<b>1.111</b>
Kyiv National University of Theater, Film and Television named after I.K. Karpenko-Kary	0.424	0.402	0.466	<b>1.098</b>
Kyiv National University of Technology and Design	0.497	0.379	0.387	0.779
Borys Hrinchenko University of Kyiv	0.452	0.335	0.426	0.942
Kyiv University of Law of the National Academy of Sciences of Ukraine	0.485	0.329	0.510	<b>1.052</b>
.....				
Kharkiv National University of Economics named after S. Kuznets	0.431	0.328	0.395	0.917
Kharkiv National Medical University	0.360	0.382	0.454	<b>1.260</b>
Kharkiv National Pedagogical University named after GS Frying pans	0.434	0.308	0.357	0.822

Analysis of the overall integrated indicators for assessing the innovative activity of HEI (see Table 1) showed that not all higher education institutions have a positive

growth rate in the 2018-2019 academic year compared to the 2012-2013 academic year. HEIs that have the maximum tendency to increase are highlighted in bold in the table and they form the core of the national higher education system. The calculation of local integrated indicators by type of activity showed that most higher education institutions have a positive dynamics in terms of educational activity, but the opposite trend is observed for other local indicators.

The revealed tendency of change of integral coefficients will allow to allocate those indicators and local indicators in the field of educational, scientific and technical, international and innovative activities to which it is necessary to pay attention at managerial decisions on increase of innovative activity of a certain HEI.

*Stage 3.* Econometric modeling was used to assess the impact of local integrated indicators of evaluation of educational, scientific, technical, innovative and international activities on the overall integrated indicator of evaluation of innovation-active HEI. The results of calculation of parameters of models of dependence of the general indicator of development of innovatively active HEI from local integrated are presented in tab. 2.

Table 2.  
The results of building an economic and mathematical model

	b*	Std. Err. of b*	b	Std. Err. of b	p-value
2012-2013 academic year (R <sup>2</sup> =0.753)					
Intercept			0.079	0.017	0.0001
<i>I<sub>osv</sub></i>	0.363	0.038	<b>0.254</b>	0.026	0.0005
<i>I<sub>scien and tech</sub></i>	0.362	0.038	0.189	0.019	0.0005
<i>I<sub>innov</sub></i>	0.586	0.0365	0.233	0.015	0.0032
<i>I<sub>international</sub></i>	0.448	0.037	0.165	0.014	0.0041
2014-2015 academic year (R <sup>2</sup> =0.796)					
Intercept			0.023	0.012	0.0651
<i>I<sub>osv</sub></i>	0.345	0.041	0.212	0.025	0.0025
<i>I<sub>scien and tech</sub></i>	0.323	0.040	<b>0.255</b>	0.032	0.0035
<i>I<sub>innov</sub></i>	0.482	0.033	0.247	0.017	0.0002
<i>I<sub>international</sub></i>	0.422	0.033	0.236	0.018	0.0012
2018-2019 academic year (R <sup>2</sup> =0,841)					
Intercept			0.057179	0.021598	0.008795
<i>I<sub>osv</sub></i>	0.243852	0.044906	0.196137	0.036119	0.001470
<i>I<sub>scien and tech</sub></i>	0.369495	0.043423	0.322592	0.037911	0.001789
<i>I<sub>innov</sub></i>	0.550734	0.043445	<b>0.493694</b>	0.015280	0.003470
<i>I<sub>international</sub></i>	0.460407	0.045032	0.231784	0.022671	0.004280

Thus, the system of economic and mathematical models of the impact of educational, scientific, technical, innovative and international activities on the general level of innovation-active educational institution are as follows:

For the 2012-2013 academic year:

$$I_{general} = 0.079 + 0.254 * I_{osv} + 0.189 * I_{scien\ and\ tech} + 0.233 * I_{innov} + 0.165 * I_{international}$$

For the 2014-2015 academic year:

$$I_{general} = 0.023 + 0.212 * I_{osv} + 0.255 * I_{scien\ and\ tech} + 0.247 * I_{innov} + 0.236 * I_{international}$$

For the 2018-2019 academic year:

$$I_{general} = 0.057 + 0.196 * I_{osv} + 0.323 * I_{scien\ and\ tech} + 0.494 * I_{innov} + 0.232 * I_{international}$$

Based on the results of the constructed models, the following conclusions can be made:

1) in the 2012-2013 academic year, the overall activity of HEI was significantly influenced by educational activities, followed by innovation. The rating of the impact of the analyzed activities on the innovative activity of HEI is presented in the form of a tuple:

$$\{I_{osv} \rightarrow I_{innov} \rightarrow I_{scien\ and\ tech} \rightarrow I_{international}\} = I_{general}$$

2) in the 2014-2015 academic year due to changes in the educational space (adoption of the law "On Higher Education") innovation-active level of the educational institution depended on scientific and technical activities, ie the system of influence was as follows:

$$\{I_{scien\ and\ tech} \rightarrow I_{innov} \rightarrow I_{international} \rightarrow I_{osv}\} = I_{general}$$

3) in the 2018-2019 academic year, the level of innovation-active free economic zone is influenced by the innovative activity of the university:

$$\{I_{scien\ and\ tech} \rightarrow I_{international} \rightarrow I_{osv}\} = I_{general}$$

All this confirms the fact that innovation today is the dominant factor in the development of higher education, the most important factor in its successful modernization in the global transformation of higher education. If earlier HEI could function successfully, focusing mainly on educational potential, today there is a need for their interaction with stakeholders, which allows to form a business-type university.

*Stage 4.* We will stratify higher education institutions at the national level by year using the clustering method. The initial information of stratification was made by 4 local integrated indicators on 193 institutions of higher education, it is proved that it is expedient to classify the initial set on 3 groups (fig. 3).

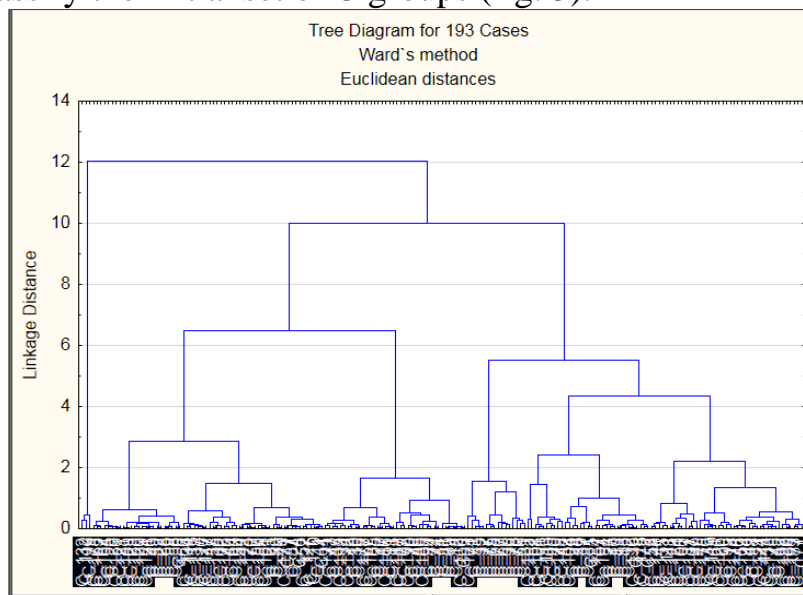


Figure 3. Dendrogram of stratification of higher education institutions for the

2012-2013 academic year

HEI stratification was carried out for the 2014-2015 and 2018-2019 academic years. A fragment of the result of HEI stratification is presented in table. 3.

Table 3.

Results of stratification of innovation-active HEIs of Ukraine (fragment)

Academic years		
2012-2013	2014-2015	2018-2019
1	2	3
<i>1 cluster of HEI with the highest innovation activity</i>		
Berdiansk University of Management and Business, Bukovynian State University of Finance and Economics, Vinnytsia National Medical University. E. Pirogov, Kyiv International University, Kyiv National Economic University named after Vadym Hetman, Kyiv National Linguistic University, National Technical University "Kharkiv Polytechnic Institute", National Technical University of Ukraine "Kyiv Polytechnic Institute", National University "Kyiv-Mohyla Academy", National University Lviv Polytechnic ", National University of Life and Environmental Sciences of Ukraine, Yaroslav the Wise National University of Law and others.	Berdiansk University of Management and Business, Bukovynian State University of Finance and Economics, Vinnytsia National Medical University. E. Pirogova, Vadym Hetman Kyiv National University of Economics, Taras Shevchenko National University of Kyiv, National Academy of Statistics, Accounting and Auditing, National Academy of Management, Bogomolets National Medical University, Kharkiv Polytechnic National University, National Technical University of Ukraine "Kyiv Polytechnic Institute", National University "Kyiv-Mohyla Academy", Kharkiv National University named after VN Karazina and others.	Berdiansk University of Management and Business, Bukovynian State University of Finance and Economics, Vinnytsia National Medical University. E. Pirogov, Vinnytsia National Technical University, Vadym Hetman Kyiv National University of Economics, Taras Shevchenko National University of Kyiv, Lviv State University of Physical Culture, National Academy of Statistics, Accounting and Auditing, National Academy of Management, Bogomolets National Medical University, Kharkiv Polytechnic Institute National Technical University ", National Technical University of Ukraine" Kyiv Polytechnic Institute "and others.
<i>2nd cluster of free economic zones with average innovative activity</i>		
Lviv National Agrarian University, Lviv National University of Veterinary Medicine and Biotechnology named after SZ Gzhytsky, Ivan Franko National University of Lviv, Mykolayiv National Agrarian University, International University of Economics and Humanities, National Aviation University, National Aerospace University. ME Zhukovsky "Kharkiv Aviation Institute" and others.	Kyiv National Linguistic University, Kyiv National University of Culture and Arts, Lutsk National Technical University, Lviv Institute of Economics and Tourism, Ternopil National University of Economics, Ukrainian State University of Chemical Technology, Kharkiv National Automobile and Road University, Kherson State University, Chernihiv National Technological University, Petro Mohyla Black Sea State University and others.	Ivan Franko National University of Lviv, Mariupol State University, International University of Economics and Humanities, National Metallurgical Academy of Ukraine, National Aviation University, Ternopil National University of Economics, Ukrainian State University of Chemical Technology, Kharkiv National Automobile and Road University, Kherson State University, Chernihiv National University of Technology and others.
<i>3rd cluster of free economic activity with low innovation activity</i>		
Vinnytsia State Pedagogical University named after Mykhailo Kotsyubynsky, Vinnytsia National Agrarian	State University of Economics and Technology of Transport, Dniprodzerzhynsk State Technical University,	Vinnytsia State Pedagogical University named after Mykhailo Kotsyubynsky, Vinnytsia National Agrarian University,

University, Glukhiv National Pedagogical University,	Dnipropetrovsk State Institute of Physical Culture and Sports,	Glukhiv National Pedagogical University
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Continuation of Table 3.

1	2	3
<p>State University of Economics and Technology of Transport Donbass State Engineering Academy, Donbass National Academy of Civil Engineering and Architecture, Ivano-Frankivsk National Technical University of Oil and Gas,</p> <p>Lviv National Medical University named after Danylo Halytsky, Mykolayiv National University named after V.O. Sukhomlinsky, International University of Science and Technology, International University of Finance and others.</p>	<p>Donbas State Academy of Mechanical Engineering, Donbas National Academy of Civil Engineering and Architecture, Donbas State Technical University,</p> <p>Donetsk State Music Academy named after SS Prokofiev, Donetsk State University of Management, Classical Private University, Kremenets Regional Humanitarian and Pedagogical Academy. Taras Shevchenko, Mykolayiv National University named after VO Sukhomlinsky, International University of Science and Technology, International University of Finance and others.</p>	<p>Dniprodzerzhynsk State Technical University, Donbas State Academy of Mechanical Engineering, Donbas National Academy of Civil Engineering and Architecture, Donbas State Pedagogical University,</p> <p>Mykolayiv National University named after VO Sukhomlinsky, International University of Science and Technology, International University of Finance, National Aerospace University. ME Zhukovsky "Kharkiv Aviation Institute", Odessa National Maritime University and others.</p>

In the 2014-2015 academic year, such HEIs as: Petro Mohyla Black Sea State University (2 → 3), Odessa National University of Economics (2 → 3), Kyiv National University of Culture and Arts (1 →) erred in their position on innovation and activity. 2), Kyiv National University of Theater, Film and Television named after I.K. Karpenko-Kary (1 → 2), Luhansk Taras Shevchenko National University (1 → 2). Such changes were related to the adoption of the new Law of Ukraine "On Higher Education", the development of the Concept for the development of higher education for the period 2015-2025, which set new goals and performance ratios for higher education on the way to European and global educational space for ensuring high-tech and innovative development of the country, the needs of society. Today the main task of innovation-active activity of the university is to acquire scientific knowledge by conducting research and development and their direction on creation and introduction of new competitive technologies, ensuring innovative development of society and training of specialists of innovative type, which in turn plays an important role in formation. ranking of the university among other HEI.

Thus, the stratification of HEI of Ukraine allowed to obtain the following results:

a set of national HEIs that constantly carry out various innovations in certain activities. As a result, they are the leading HEIs in the world rankings and occupy high positions in national rankings. Such HEIs are the driving force of further development of the national system of higher education in the direction of integration into the world educational and scientific space;

The obtained values of integrated performance indicators of HEI of Ukraine establish not only the rating of universities according to the level of their innovative activity, but can also be used as reference values for HEIs with a lower rating. That is, on the basis of the obtained values in further research will be formed systems of



management decisions to support and further strengthen the innovation activity of a particular HEI within their resource constraints..

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