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Monitoring and modeling of infrastructure indicators development of united territorial communities`

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SUMMARY

A study of the dynamics of state support for infrastructure development of UTC, development expenditures (capital expenditures) and the effectiveness of the current mechanism for calculating the infrastructure subvention on the example of Zaporizhya region and identified the relationship between infrastructure subvention and development expenditures (capital expenditures). It is established that the current mechanism for determining the size of the infrastructure subvention, when it is determined depending on the size of the rural population and the area of UTC is ineffective. It is proved that it is necessary to assess the parameters of sustainable development of OTG not only by traditional components, which are economic, environmental and social, but also by the infrastructural component. For this purpose, an integrated indicator of sustainable infrastructural development of each individual UTC, district or region is proposed, which would allow comparing OTG indicators not only within a district or region, but also between regions of Ukraine. Its definition is carried out using the apparatus of fuzzy set theory.

Introduction

A study of the support conditions for united territorial communities` (UTCs) sustainable development is relevant. It requires appropriate justification for the infrastructural support of reforms, development of scientific principles and recommendations aimed at optimal application of natural resources and socio-economic potential at the sub-regional stage of reforms. Taking into account that infrastructure suffered the most damage at the beginning of the war, the study results can be used to form a model of post-war recovery.

Method

In the analysis, general-scientific methods (analysis and synthesis, induction and deduction) and special methods of phenomena and processes analysis (abstraction, econometric and econometric-mathematical modelling) have been used.

Results

We studied the dynamics of state support for UTCs` infrastructure development, development (capital) expenditure, and the effectiveness of current infrastructure subvention mechanism, applying the case of Zaporizhzhia region (Fig. 1).

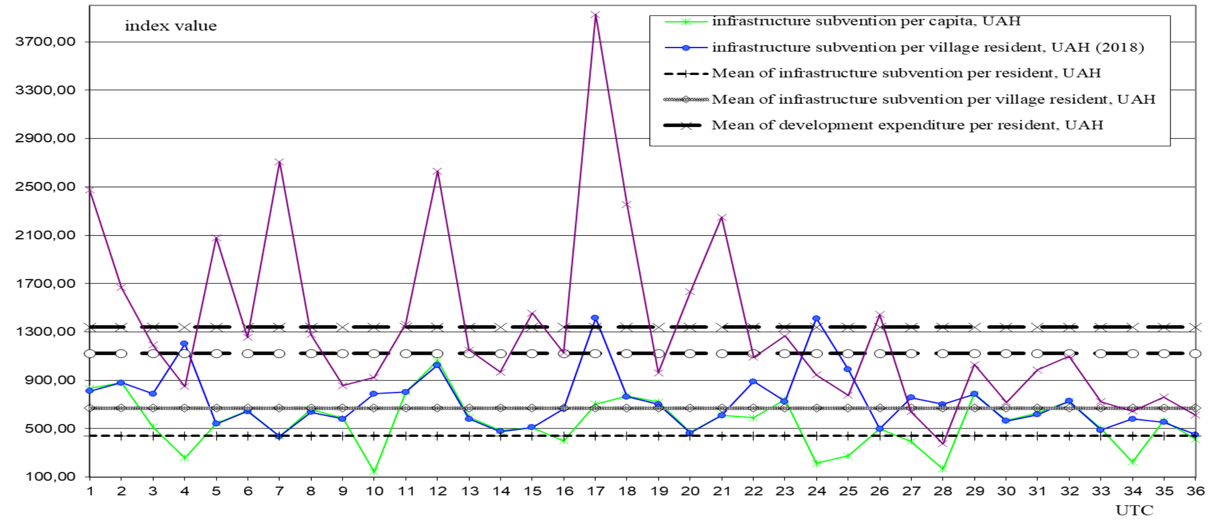

***Figure 1** Dynamics of infrastructure subvention changes per village resident and per UTC resident, development expenditure and corresponding mean for thirty-six UTCs of Zaporizhzhia region in 2018*

1 – Smyrnovska; 2 – Berestivska; 3 – Kamysh-Zarianska; 4 – Veselivska; 5 – Voskresenska; 6 – Preobrazhenska; 7 – Dolynska; 8 – Botiivska; 9 – Osypenkivska; 10 – Prymorska; 11 – Ostrykivska; 12 – Hirsivska; 13 – Malotokmachanska; 14 – Bilenkivska; 15 - Tavriiska; 16 - Komyshuvaska; 17 - Kyrylivska; 18 – Pidhirnenska; 19 – Vozdvyzhivska ; 20 - Shyrokivska; 21 - Velykobilozirska; 22 - Chernihivska; 23 - Chkalovska; 24 - Pryazovska; 25 – Gulyaipilska; 26 – Pavlivska; 27 – Yakymivska; 28 – Orikhivska; 29 - Novooleksiivska; 30 – Petro-Mykhailivska; 31 -Plodorodnenska; 32 - Novouspenivska; 33 - Novobohdanivska; 34 – Kamjansko-Dniprovska; 35 - Blahovischenska; 36 – Vodyanska

Comparison of the average infrastructure subvention per village resident and per person with development expenditure, calculated as a simple mean and as an arithmetic mean is presented in Fig. 2. As one can see, during the analyzed period the specific values of infrastructure subvention (per village resident and per resident) decreased. At the same time, the specific values of development expenditure grew in 2017, but they also fell in 2018. Thus, the analysis of infrastructure development indicators of Zaporizhzhia region`s united territorial communities revealed the dependence between the infrastructure subvention and development (capital) expenditure. It was found out that the UTCs, which have significantly lower infrastructure subvention per person than the corresponding value per village resident, have much lower development expenditure. UTCs characterized by infrastructure subvention close to the lower limit of regional mean in the corresponding year, have significantly lower development expenditure as well. This, in our opinion, means that the UTCs get infrastructure subvention based on the number of rural residents and the UTC area, but spend these funds to meet the needs of the entire population of the community.

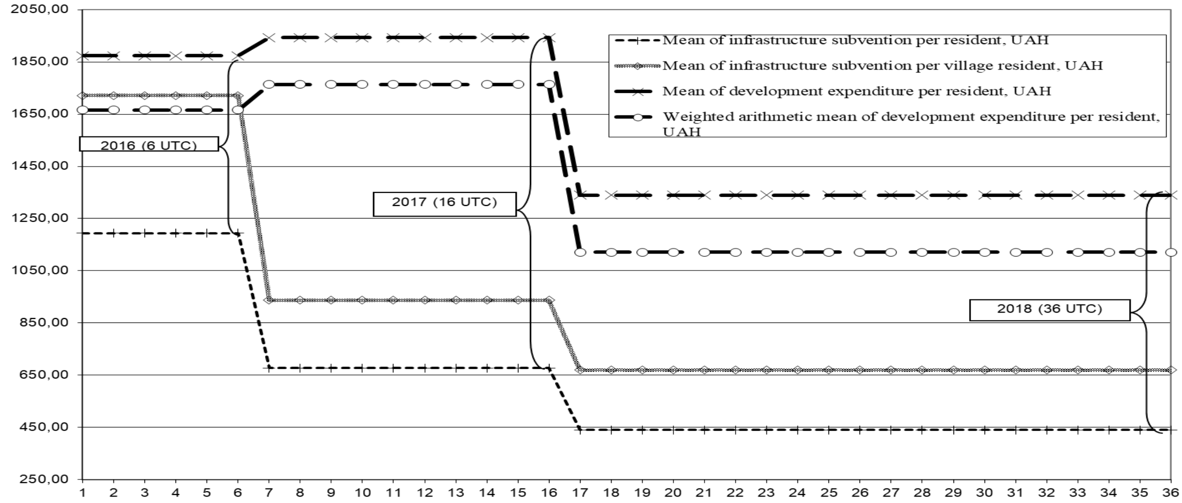

Figure 2 *Mean of infrastructure subvention per village resident and UTC resident, development expenditure for UTCs of Zaporizhzhia region during 2016 – 2018s*

As a result, they form additional burden on the expenditure component of the budget, because there is a need for their territory`s infrastructure facilities funding.
Therefore, it is necessary to assess the UTCs sustainable development parameters not only applying traditional components, i.e. economic, ecological and social, but adding the infrastructural component. We believe, that to do this, it is appropriate to propose an integral indicator of sustainable infrastructural development of each UTC, district or region, which would allow to make comparisons of UTC indicators not only within the district or region, but also between the regions of Ukraine.
The integral indicator for the assessment of infrastructure sustainable development should take into account two components: external impact of infrastructure subvention and internal UTC capacity of development expenditure.
In turn, the amount of state infrastructure subvention according to the current procedure is determined by the UTC`s territory and the number of rural residents, but in the proposed model it is advisable to recalculate it not on the basis of rural residents number (as it is made), but taking into consideration total UTC`s population in accordance with actual expenditure.
Taking into account multi-criteria and the need to flexibly assess the traditional methods parameters, it is not possible to assess economic phenomena and processes in natural and economic systems. The situation arises when it is necessary to flexibly evaluate numerical indicators taking into account, for example, several scenarios of the expected outcome: pessimistic (a_{pes}), optimistic (a_{opt}) and most likely (a_{ml}). To solve the tasks, it is possible to use the theory of fuzzy sets proposed by Lotfi Zadeh in 1965.
In general, income as an indicator can be assessed as pessimistic (a_{pes}), optimistic (a_{opt}) and most likely (a_{ml}). The received information can be combined in the form of a triangular fuzzy number $A = (a_{pes}, a_{opt}, a_{ml})$. Then, fuzzy numerical results are compared with indicators for other objects.
Fuzzy set A is determined by the membership function $\mu_A (x)$, which accepts all the intermediate values between 0 and 1, which specify to what extent element x belongs to a fuzzy set A. Unlike regular sets, there are intermediate membership degrees, for example, $\mu_A (x) = 0{,}5$.
Assume that a fuzzy set A is normalized, so there is set $\mu_A (x) = 1$. If it is the case of two fuzzy sets A and B, membership functions can be represented as: $\mu_{A\cup B} (x) = max (\mu_A (x), \mu_B (x))$, $\mu_{A\cap B} (x) = min (\mu_A (x), \mu_B (x)), \mu_{\bar{A}} (x) = 1 - \mu_A (x)$, for fuzzy union $A\cup B$, intersections $A\cap B$ and complements $\bar{A}$.
Actually, there are triangular and trapezoidal fuzzy numbers. The named factors of the model of infrastructure sustainable development integral indicator should be represented as a fuzzy set, since each can take three possible values: for an UTC; to be determined as mean for a region (simple mean as the ratio of total subsidy to the population or UTC area); to be defined as weighted arithmetic mean

to the corresponding area or population. So, in each of the two cases, we have a triangular fuzzy number. Similarly, one can represent the development expenditure per capita with a triangular fuzzy number: a UTC value, mean for a region (simple mean) or weighted arithmetic average to the corresponding UTC population.
To determine regional or district level of sustainability, in our opinion, there is a need to take into account the specific weight of each of the three components: infrastructure subvention per UTC resident, infrastructure subvention per square km of an area and development expenditure per resident. And it is expedient to apply expert analysis here.
The obtained integral value of the level of infrastructural development corresponds to the sustainability level. Its value should be 1 and above. The actual value of the level of infrastructural development should be assessed by two indicators: infrastructure subvention per UTC resident and infrastructure subvention per square km of an area. The value allows to assess the effectiveness of state financing of territory's infrastructure development. Based on the estimate according to the formula for calculating the infrastructure subvention with equal parameters of population and area, it is advisable to determine the weight factor as 0.5. Taking into account the third indicator (development expenditure) includes the assessment of the level of UTC`s or region`s (district`s) infrastructure development sustainability in general and requires determining the appropriate weight factor. We consider that at the initial stage of decentralization, it would be appropriate to have 50/50 weight distribution of state influence and internal capacity. So, the weight factor will be 0.25 for infrastructure subvention per UTC resident, respectively; 0.25 for infrastructure subvention per square km of an area and 0.5 for development expenditure per resident.
In the future, there is an opportunity to model the situation`s development by varying the weight factor by increasing the weight of development expenditure per resident, which is a condition for community`s self-sufficiency due to lower dependence from state funding. At the same time, it is expedient to control the efficiency of state financing of infrastructure development and make assessment for the two-factor model.
We compared the indicators of UTCs infrastructure development in Zaporizhzhia region during 2016-2018s (fuzzy values). The calculation results for 2018 are presented in Table. 1. The integral assessment of the level of infrastructure development sustainability was determined in 2018 based on the following weight factors: 0.25 for infrastructure subvention per UTC resident; 0.25 for infrastructure subvention per square km of an area, and 0.5 for development expenditure per resident.
State support for UTCs infrastructure development in Zaporizhzhia region in 2018 decreased. Development expenditure generated by own revenues allowed to increase the level of infrastructure development sustainability to 0.9912 (2017th level). The last column of the table illustrates parameters of the modelled infrastructure sustainable development amid the following factor weights: 0.075 for infrastructure subvention per UTC resident; 0.075 for infrastructure subvention per square km of an area, and 0.85 for development expenditure per resident. As one can see, the level of 1.0012 was reached by the distribution (0.999 in the previous year). It means that territory`s sustainable infrastructure development was ensured by UTC's own financial resources.
Comparison of the integral assessment indicators of UTCs infrastructure development sustainability in Zaporizhzhia region revealed that during 2016-2018s as a result of stronger UTCs` self-sufficiency the level of infrastructure development sustainability rose despite the decrease in state funding.

Conclusions

Dynamics of state support for UTCs` infrastructure development, development (capital) expenditure and the effectiveness of current infrastructure subvention mechanism was studied using the case of Zaporizhzhia region. Dependency between the infrastructure subvention and development (capital) expenditure was found out. It was proved that current mechanism for determining the amount of infrastructure subvention based on rural residents and UTC area is not efficient. It was demonstrated that it is necessary to assess the parameters of UTCs sustainable development not only using traditional components, which are economic, ecological and social, but also by the infrastructure component. To do this an integral indicator of a UTC`s, district`s or region`s sustainable infrastructure development was proposed, which would allow the comparison of UTC indicators not only within district or region, but also between the regions of Ukraine. It is calculated applying the theory of fuzzy sets` toolkit. Comparison of the indicators of UTCs` infrastructure development in Zaporizhzhia region during 2016-2018s (fuzzy values) was carried out. It showed the higher level of UTCs` break-even and self-sufficiency, as well as of the level of territory`s infrastructure development sustainability.

Table 1 *Assessment of the indicators of infrastructure development of Zaporizhzhia region UTCs in 2018 (fuzzy values)*

UTC	Development expenditure per UTC resident	Infrastructure subvention per square km of UTC area	Infrastructure subvention per UTC resident	Integral assessment of infrastructure subvention efficiency	Integral assessment of UTC infrastructure development sustainability	Optimal value of UTC infrastructure development sustainability
Smyrnovska	1,504852	0,9147121	1,285343	1,100028	1,302439576	0,956408
Berestivska	1,211532	0,8901025	1,327795	1,108949	1,160240163	0,939343
Kamysh-Zarianska	0,979219	0,923443	0,952399	0,937921	0,958569971	0,926701
Veselivska	0,769052	0,8294336	0,569113	0,699273	0,734162857	0,800148
Voskresenska	1,374394	1,1064259	0,987136	1,046781	1,210587747	1,093006
Preobrazhenska	1,013579	1,0117092	1,108245	1,059977	1,036778017	1,022569
Dolynska	1,571528	1,2956963	0,850496	1,073096	1,32231202	1,245611
Botiivska	1,026323	1,0093041	1,118155	1,063729	1,045026111	1,02155
Osypenkivska	0,775036	1,0578734	1,035437	1,046655	0,910845468	1,055349
Prymorska	0,819585	0,9229326	0,340926	0,631929	0,725756882	0,857457
Ostrykivska	1,069263	0,9178437	1,258114	1,087979	1,078621162	0,956124
Hirsivska	1,550353	0,8529306	1,467753	1,160342	1,355347309	0,922098
Malotokmachanska	0,955663	1,0572599	1,047073	1,052166	1,003914708	1,056114
Bilenkivska	0,846486	1,20215	0,90991	1,05603	0,951257874	1,169273
Tavriiska	1,115391	1,1470873	0,945822	1,046454	1,080922907	1,124445
Komyshuvaska	0,942905	0,9885346	0,792386	0,89046	0,916682521	0,966468
Kyrylivska	1,844275	0,7976965	1,165243	0,98147	1,412872263	0,839046
Pidhirnenska	1,466914	0,9336049	1,229744	1,081675	1,274294458	0,966921
Vozdvyzhivska	0,843026	0,9661107	1,180405	1,073258	0,958141729	0,990219
Shyrokivska	1,196416	1,2289574	0,892887	1,060922	1,128668771	1,191149
Velykobilozirska	1,432612	1,0312366	1,067653	1,049445	1,241028213	1,035333
Chernihivska	0,921771	0,8874741	1,042826	0,96515	0,943460345	0,904951
Chkalovska	1,019971	0,9532457	1,199384	1,076315	1,048143084	0,980936
Pryazovska	0,833341	0,7978153	0,482866	0,640341	0,736840967	0,762384
Gulyaipilska	0,719015	0,8609087	0,596801	0,728855	0,723934841	0,831196
Pavlivska	1,108923	1,1644447	0,933639	1,049042	1,078982614	1,138479
Yakymivska	0,620204	0,93701	0,785419	0,861215	0,740709214	0,919956
Orikhivska	0,397218	0,9663008	0,395029	0,680665	0,538941567	0,902033
Novooleksiivska	0,88498	0,9240249	1,246608	1,085317	0,985148108	0,960316
Petro-Mykhailivska	0,677544	1,0765477	1,013158	1,044853	0,861198496	1,069416
Plodorodnenska	0,85823	1,0242134	1,087768	1,055991	0,957110335	1,031363
Novouspenivska	0,926149	0,9513996	1,18849	1,069945	0,998046588	0,978072
Novobohdanivska	0,681701	1,1812729	0,929111	1,055192	0,868446532	1,152905
Kamjansko-Dniprovska	0,622886	1,0582824	0,506811	0,782547	0,702716201	0,996242
Blahovischenska	0,70868	1,0719977	1,012621	1,042309	0,875494704	1,065318
Vodyanska	0,597046	1,2599477	0,811113	1,03553	0,816288195	1,209454
Total for region				**0,985606**	**0,991220348**	**1,001065**