

Based on Ukrainian universities, implementing the developed methodology was achieved as of the spring 2022. As revealed by monitoring of the situation, 32 percent of universities are able to provide higher education services at a sufficiently high level. The aim of the study is to optimise the provision of high quality and socially responsible higher education under martial law. The potential beneficiaries of the research results are students and teachers of Ukrainian higher education institutions located in territories under various degrees of military threats. Optimising the social responsibility system of service provision will improve the quality and reliability by 10 per cent and identify points of growth and stabilisation of at least 15-20 percent.

Keywords: driver indicators; on-line education; Internet sources; war

JEL: C 31; I 23; H53

1. Introduction

War and conflict have a systemic impact on higher education in any country (Akdağ et al., 2018). University buildings are damaged by attacks or invasions (Ashour, 2022). Staff and students are killed or threatened with forced displacement. University provision is weakened as post-conflict financial resources are prioritised for basic needs (Asderaki, 2019). Experience in countries emerging from armed conflicts shows that, in most cases, higher education systems are not a priority during post-conflict reconstruction (Ayoubi et al., 2011).

Universities are more likely to suffer in war to a greater extent than any other institution. This is due to the restriction of academic freedoms and a massive brain drain shaped to the flight of cutting-edge academics, teachers, and students (Kearney et al., 2012). According to the experience gathered by war-torn countries, it appears difficult or impossible for higher education systems to reproduce the human capital required for national reconstruction (Kember et al., 1991).

A system-wide approach (Knysh et al., 2020), meaning a collective effort (Kester, 2013), is needed to ensure high-quality higher education in war circumstances. Notably, a combination of factors justifies the relevance of this research. From a theoretical point of view, the potential for developing and applying new technologies of higher education provision opens under martial law (Lange, 1986).

In the practical context, an algorithm is developed to cluster educational services according to the level of social responsibility achieved (Kwiek, 2014). Its implementation will initiate a new tool to use the drivers of university organisations on corporate-social principles under martial law (Lebeau et al., 2015).

Martial law is a special legal regime introduced in Ukraine or in certain areas thereof in case of armed aggression or threat of attack, danger to state independence, territorial integrity and provides for granting relevant state authorities, military commanders, military administrations and local self-government bodies the powers necessary to prevent the threat, repulse armed aggression and ensure national security, as well as temporarily limiting the constitutionality of the state of emergency.

Under martial law, ensuring the social responsibility of providing higher education services requires the heads of departments (divisions) of education and science of regional state

administrations, higher, professional higher and professional (vocational) education, enterprises, institutions and organisations, included in the MES management area, to implement the following measures:

- 1) Provide educational services in the determined volumes, in accordance with the determined educational programmes and plans;
- 2) organise the quick resumption of the educational process in case of its interruption as a result of military operations;
- 3) to notify the administration of higher education institutions, students and teachers about the occurrence of an emergency situation: military threat, shelling, bombing;
- 4) inform about possible consequences, ways and methods of protection, actions in the area of a possible emergency situation;
- 5) involve additional forces and means of protection of students and teachers in case of emergency situations;
- 6) create and use material reserves to prevent emergencies and eliminate their consequences;
- 7) immediately notify students and teachers, educational authorities, civil defence of the Regional State Administration, territorial bodies of the Security Service, the State Emergency Service and the Ministry of Education and Science of the threat of an emergency situation, disruption of the functioning of the university or the threat of termination of the provision of educational services;
- 8) in case of an immediate threat to the life and health of students and teachers at the HEI, put in place an Evacuation Plan for the educational institution.

Thus, the study of social responsibility and the new drivers of university organisation on corporate-social principles under martial law poses an urgent research issue. The study aims to develop models of optimisation of higher education provision by the level of social responsibility under martial law. The objectives of this study are as follows: to cluster the territories of Ukraine on the level of social responsibility and the possibility of providing higher education services under martial law; to propose optimal models of operation of higher education institutions (HEIs) under martial law. The place of the study is Ukraine; the study period is February – March 2022.

2. Literature Overview

The experiences gained by various countries in organising education services in war circumstances constitute grounds for their division into two groups.

The first group is dominated by the number of successful examples of a country's education recovery from a military crisis (Mckenna, 2006). Within the group, illiteracy was prevalent at the outbreak of hostilities (Moore, 1997). This group consists mainly of countries in Southeast Asia and Africa. Such countries as India, Pakistan, Bangladesh, and Sri Lanka developed and successfully implemented 5-year education plans (Zgaga, 2013). The main

objectives of those plans included achieving universal primary education practices, eradicating illiteracy, establishing vocational and skills training programs, raising standards, modernising all levels of education with an emphasis on technical education, science, and environmental education, and providing high-quality education in every district of the country. And education was commonly free, anywhere from kindergarten to the university level. In sub-Saharan Africa, education ranged from simple homeschooling (Kalahari tribes) to the sophisticated education system of the highly organised society in West Africa (Liberia, Sierra Leone, Guinea). Since African countries won their independence at the end of the 20th century, they have abolished racial segregation and carried out reforms. Modern education in these countries can be seen in terms of a former colonial status, except in Ethiopia, Liberia, and South Africa. In Ethiopia, the most progressive transformations have taken place. The aims of education were stated as follows: education for production, education for scientific consciousness, and education for social consciousness (Vargas-Hernández et al., 2016).

Looking at the past from today's perspective, the following trend can be observed - violent conflicts are characteristic of playing a significant role in deepening crises in higher education, as well as in general. We are talking about the fact that in the last decade, the spread of national and international conflicts in the Middle East, Africa, Eastern Europe, Latin America, the Balkans and South-East Asia has posed many challenges to higher education systems, among them considerable humanitarian losses, destruction of infrastructure, and psychological trauma resulting from prolonged exposure to high-risk zones (164). It is telling enough that, according to the Institute for Economics and Peace, among the 162 countries in the world in 2014, only 11 had nothing to do with the conflict.

The second group of education reforms includes various strategies and plans to overcome the war crisis in countries where the education system, including higher education, had been well-developed before the war started (Stevens et al., 2021). As an example, the Chicago Plan for undergraduate education reform might be mentioned. It was proposed in the United States during the Second World War. The plan offered an accelerated two-year education form where freshmen were attached to undergraduate instructors. The program's aim was not to prepare young people only for war but also for the reconstruction of the country. As a result, the majority of developed countries reduced the undergraduate training period from four to three years (White, 1982; Zhou et al., 2021). Separate examples are the impact of the late 20th and early 21st century color revolutions on a country's education system (Trespalacios et al., 2021). For instance, Iraq's education system under Saddam Hussein was open to all population segments, including women. Since the imposition of international sanctions in the 1990s, it has been virtually destroyed (Mason, 2000). The US invasion brought the infrastructure (equipment, libraries, buildings) of almost all Iraqi universities to ruin. Taken together, the intellectual and historical legacy of Iraqi higher education has been lost. Many university staff members were kidnapped and murdered, while students faced threats and intimidation from fundamentalist militia groups (Moore, 2009). As another example, one may cite the education crisis (Al Lily et al., 2020) triggered by the COronaVirus Disease 2019, coronavirus infection 2019-nCoV (Covid-19) pandemic that, in fact, prepared the education system of all countries of the world to exist in a demanding restrictive institutional environment (Popa et al., 2020). During the two years of the pandemic, the experience of distance learning was successfully incorporated (Tavangarian et al., 2004). Countries used various options and combinations. To name a few, e-learning (Sun et al.,

2020) or online learning (Singh et al., 2019), where the Internet is the learning environment, virtual learning applied in courses where learners study outside the classroom (Sharpe et al., 2006), distance learning for those studying individually by post (Zhu et al., 2020), and open learning through the open-university system (Sabzalieva, 2017).

Based on the experience of the functioning of the higher education system during and after the war, in our view, we should try to implement the experience of incremental functioning in different countries (Asderaki, 2019; Ashour, 2022; Ayoubi; Massoud, 2011). The essence of this approach is that different parts of the system are developed at different times and rates, and if one part is ready, then it is integrated into the system.

The possibility of using the experience of incremental higher education functioning in the context of military operations in Ukraine is limited by the unpredictable consequences of the new policy; the regulation of the procedure of transition to new conditions of higher education provision; insufficient resources and instability of the system of social responsibility of universities and the state to the participants of the educational process. It is obvious that this model is more plastic, as it allows changing individual elements of the proposed action without radically restructuring other elements.

The relationship between the level of education, mutual social responsibility and the degree of conflict in a society has been studied by many scholars (Trespacios et al., 2021; Zgaga, 2013). For example, (Van Rooij, 2012) suggests that a high level of intellectual culture ensures quality communication, social awareness and responsibility in a conflict society. This scholar attributes this correlation to the fact that a person with deep knowledge, multiplied by a personal desire for justice, will not engage in any form of aggression, including warfare. Conversely, people with a low level of education, according to (Stevens et al., 2021), are more easily involved in military conflicts, as a lack of ability to think critically about complex conflict situations in society reduces their level of social responsibility and allows them to be easily manipulated.

These theses were confirmed by Ukrainian scholars (Oleksiyenko et al., 2021; Zhuravka et al., 2021), who investigated the experience of hostilities in Ukraine in 2014-2021. They concluded that it was the level of teaching in displaced universities and the degree of social responsibility of the academic community and the state to provide the necessary resources for the higher education system that solved the difficult problem of peacebuilding, fostering students' love and respect for all citizens of their state and the world as themselves.

Many authors (Kwiek, 2014; Lebeau et al., 2015) agree that the social responsibility of higher education institutions lies not only in the possibility of open and inclusive access to educational services for all categories of the population. Using this approach allows students to develop skills of non-violent interaction in the academic environment, empathy, empathy for the opponent, and personal responsibility. Thus, the academic community is a fertile environment for teaching the younger generation effective communication strategies in the discussion, where all participants in a conflict situation can reach a consensus by awakening compassion for their opponents, operating with critical thinking and applying emotional intelligence. The purposeful development of such qualities increases the level of social reciprocity of both students and teachers.

A Ukrainian scientist (Hladchenko, 2020) proposed a concept of science education based on the principles of social responsibility, inclusiveness, and peacebuilding. This concept represents the reformatting of a strictly deterministic higher education system into a demand-driven, branching system of knowledge generation and dissemination based on the observance of a socially responsible individual trajectory of the educational process. This approach allows students to demonstrate such socially responsible skills as tolerance, curiosity, initiative, mental acuity, creativity, and critical thinking. The transition from standardised knowledge and regulated behaviour to free analytical searching, research, experimental, design and inventive activities under the rules of socially responsible interaction brings modern education closer to real life, and its entrants acquire the sustainable motivation to know themselves through the prism of the complex world.

The opening of Science Education Chairs, Peacebuilding and Social Justice Research Centres, supported by UNESCO, will mobilise and engage the academic power of universities to address existing societal problems in local and global dimensions. Further research into the phenomenon of science education in the context of peacebuilding could be undertaken using sociological verification methods, which would reveal the current level of awareness of research and teaching staff on these issues. Of particular research interest could be the issue of updating the content of future teachers' curricula with regard to ensuring their awareness of the theory of science education and based on their awareness of the role of science education in the civilisational processes of the 21st century.

The historical experience of the relocation of universities from the First and Second World Wars has shown that any evacuation is inherently force majeure, which has a disruptive effect on the teaching and learning process and academic work (Islam et al., 2021). Even a temporary suspension of normal university functioning requires a long period of rehabilitation, which in some cases may take years. The problem of a displaced university has to be seen in the coordinates of two cities – the one from which it evacuated and the one to which it moved. In fact, through relocation one solved not one but two problems simultaneously: on the one hand, saving university property and empire-loyal staff from the enemy, and on the other, reinforcing higher education in the regions to which the university was evacuated. A ramified university organism cannot be relocated in its entirety in the short term - there will always remain a certain proportion capable of self-reproduction over time. In a situation of ideological confrontation, this means that a previously cohesive university splits into distinct parts oriented towards extremely opposite, even antagonistic, attitudes. Reintegration with “their” universities in the occupied territory is currently impossible.

From the perspective of (Oleksiyenko et al., 2021), attempts to return displaced higher education institutions to Ukraine are still only in draft form. No one is waiting for displaced universities there. Rather, it is advisable to talk about the integration of displaced universities into the educational and scientific landscape of Ukraine, which has already passed. But when reintegrating, we should not lose the positive assets of the relocated universities; we should preserve our educational and mental peculiarities, the spirit of “Alma Mater”. The ordeal that has befallen our people will make the already strong Donbas and Crimean universities even stronger, more competitive and creative.

In terms of ensuring the social responsibility of higher education on the part of the state, it is necessary to develop and implement a system of resources, information and logistical support for higher education institutions in the new environment (Hladchenko, 2020).

In the absence of a clear state strategy for the development of displaced institutions of higher education and with a lack of funds to strengthen their physical facilities, the question of saving these educational centres and preserving their own identity is in their hands. Success in preserving their own position in an increasingly competitive educational market will depend on the ability of professional teams of displaced educational institutions to offer Ukrainian society and local communities their newest mission of cultural reintegration of Donbas. In this sense, displaced universities have an opportunity to acquire a new role and social significance not only as centres of education and science, but also as centres of culture and social activism, as places of social dialogue, and as innovative platforms for finding strategies for overcoming conflicts between citizens with non-identical, sometimes diffused identities. The development of accompanying services that displaced universities can provide to local communities will transform them from recipients of assistance from government and local authorities into providers of new services and creators of new meanings of contemporary Ukrainian reality. The displaced institutions of higher education continue to perform primarily an educational function. Apart from the standard process of training future highly qualified specialists among Ukrainian youth, in the territories of Donetsk and Luhansk regions, teachers of displaced institutions of higher education have to “fight for the consciousness” of their future students. It should not be forgotten that all displaced institutions of higher education, who have demonstrated their loyalty to Ukraine by their move, are in one way or another not just educational institutions, but also a powerful weapons in the information war against Russian propaganda. It is they who are the rehabilitation centres capable of effectively “sanitising the minds” of locals who are still hostile to the Ukrainian government.

Based on the current state of the Ukrainian educational system, divided by the war, the main way of reintegration is to establish effective support systems for displaced institutions of higher education with improved material, a technical and scientific-pedagogical component of their activities. Thus, the relevant objectives of reintegration policy are: 1) Establishing an effective system for displaced institutions of higher education in their new locations; 2) Expanding and upgrading the logistical, organisational and methodological base of displaced SAIs; 3) Preparing displaced institutions of higher education to return to the liberated territories; 4) Developing and implementing systematic measures to support youth from the occupied territories, encouraging them to join displaced institutions specifically.

Hladchenko, 2020; Knysh et al., 2020; Oleksiyenko et al., 2021 suggest different scenarios for ensuring the socially responsible provision of higher education institutions in situations of military conflict. The use of one scenario or another depends on many factors: the location of the institution, and the presence or end of a military conflict at the current point in time (Ashour, 2022; Ayoubi et al., 2011; Kember et al., 1991).

The «Internal Resources» scenario, for instance, is based on the principle of strengthening the social responsibility of the work of the displaced universities at the expense of the state. This scenario implies that the military conflict is not over and, therefore, universities need to be relocated from the active war zone. Many researchers (Sabzalieva, 2017; Vargas-

Hernández et al., 2016) believe that to ensure social responsibility and quality of educational services provision, active state support of displaced universities by creating nationwide programmes to support them, unifying curricula, introducing best domestic teaching practices, attracting socially responsible teachers with relevant experience is necessary.

The second version of the «International Support» scenario is applicable when active hostilities are over and the support of the international community is needed for higher education institutions to recover (Corbett, 2014; Evans, 2010; Jegede, 1994). The essence of this scenario is to spread the practice of involving international experts, and foreign teachers, adapting foreign experience of ensuring socially responsible provision of education at a high level. This scenario involves the state delegating the tasks of supporting displaced higher education institutions to foreign (international) organisations while retaining control over social responsibility standards and quality of education, planning, monitoring and improving education policy. The scenario envisages organisational and financial assistance to displaced universities by state and non-state foundations.

The third hybrid scenario combines elements of the previous two scenarios. It is applicable if the military conflict has entered the recessionary phase. This approach, in terms of (Kearney et al., 2012) represents, on the one hand, the use of the state institutional structure of social responsibility of providing high-quality educational services to displaced universities, on the other hand, the involvement of material, informational, the methodological capacity of non-state and foreign organisations. From the point of view of (Ganushchak-Yefimenko et al., 2017), the simultaneous use of this scenario can be realised through the use of the methodology of competitive integrative benchmarking of higher education institutions. This approach allows, on the one hand, to find and copy the best practices of international universities to solve similar problems and, on the other hand, to rationally use the resources available to universities.

This requires examining the needs of each individual displaced university and proposing a phased and flexible strategic benchmarking plan. In this scenario, the monitoring of support policies for displaced universities and the objective assessment and rapid adjustment of relevant areas for improvement are of particular importance.

Since the start of the invasion by Russian troops, the educational process in educational institutions of all levels was suspended for a fortnight. During this period, there was a temporary occupation of some territories. According to the United Nations International Children's Emergency Fund (UNICEF), about 7 million people became refugees. Notably, more than half of them were internal migrants, and about 40 percent were external. And the bulk of refugees were women and children. On March 10, 2022, the Ministry of Education and Science of Ukraine (MESU) launched an interactive map with educational institutions in Ukraine destroyed and damaged by Russian actions. As of March 31, 76 educational institutions in Ukraine were completely destroyed, and 722 were damaged (Table 1).

Table 1. State of the Infrastructure of Educational Institutions in Ukraine as of 24.02. – 01.04.2022

Infrastructural facilities for education	Damaged	Destroyed
Pre-primary education establishments	263	7
Secondary and special education establishments	356	61
Establishments providing out-of-school education	17	1
Vocational education establishments	45	5
Vocational higher education establishments	22	1
Higher education establishments	18	1

According to these data, some regions (Kharkiv, Donetsk, Sumy, and Kyiv) accounted for most of the damage to property and buildings of educational institutions. At the same time, this did not prevent the restoration of the educational process since March 14. Classes took place mainly in remote mode. Universities in those regions were able to organise the educational process so that teachers could conduct it from any region. In addition, for those universities where the academic process could not be restored, it was decided to transfer students to universities in Ivano-Frankivsk, Lviv, Ternopil, Rivne, Volyn, Dnipro, and Khmelnytsky regions on the principles of academic mobility. In this respect, the experience of the evacuation of Ukrainian universities in 2014 (Oleksienko et al., 2021), when most of the universities in Donbas and Crimea were relocated to safer areas, should be considered. For instance, it stands to mention moving the Donetsk National University to Vinnitsa, the State Biotechnology University to Transcarpathia, the Volodymyr Dahl East Ukrainian National University to Kamyanets-Podilsky, and the Luhansk Medical University to Rivne. Many EU countries (Lithuania, Latvia, and Estonia) offer scholarships and various academic programs for students and teachers from Ukraine. Moreover, in March 2022, the World Bank allocated 100 million hryvnias to support students. Poland created the Ukrainian Global University project suggesting Ukrainian students, researchers, and teachers to join the programs of foreign universities and institutes. MESU has set up a Telegram bot where news on the employment of scientists and teachers at universities abroad is published.

Elsevier provides Clinical Key, Complete Anatomy and Osmosis electronic platforms for Ukrainian medical professionals. Ukrainian scientists have also been given access to electronic resources that are available as part of the Global Access to Research in health, food and agriculture, environment, innovation and law (Research4Life) project. To summarise, currently, many ideas are offered to realise the possibility of using various technologies to deliver higher education in a socially responsible way. Nevertheless, there is still a need to analyse the effectiveness of different drivers for organising universities on corporate-social principles under wartime conditions.

Thus, the aim of this paper is to find a new tool for clustering the quality of higher education services according to the level of social responsibility achieved. The practical application of this tool will make it possible to determine the effective complementarity of the drivers applied to arrange higher education services on social principles under martial law and propose an approach to identify the activator/deactivator indicators of this process.

3. Methodology

Data collection and development of recommendations on arranging the provision of higher education under martial law was based on open Internet sources, official data of MESU, processing of data of the online survey among higher education stakeholders conducted in the form of a Google table.

The processing of 200 questionnaires made it possible to identify the main indicators affecting the opportunities and stakeholders' perceived expectations to receive higher education under martial law, the costs of universities to ensure this process.

While building a model (M.1) of clustering the quality of higher education services by achieving a level of social responsibility under martial law, the following indicators were used (Table 2).

Table 2. Inputs for building a model for clustering the quality of higher education services according to the level of social responsibility achieved under martial law

Indicators	Designation
Security of higher education provision	X ₁₁
Quality of higher education provision in the context of war	X ₁₂
Availability of the Internet	X ₁₃
Relevance of information and communication technology to the required quality level of higher education provision	X ₁₄
Loyalty and trust of stakeholders to the university	X ₁₅
Ability to ensure a living wage for the university staff	X ₂₁
Need to evacuate the university	X ₂₂
Costs of relocating the university	X ₂₃
Possibility of obtaining scholarships for students from EU universities	X ₂₄
Costs of providing higher education services related to distance working conditions, martial law	X ₂₅

The indicators in Table 2 were assessed as follows.

For the indicators that require ranking according to the degree of correspondence of the answer to the required result, the following five-point scale was used: 1 (Difficult to answer); 2 (No); 3 (More likely no); 4 (More likely yes); 5 (Yes). This group of indicators includes:

- “Availability of the internet”;
- “Relevance of information and communication technology to the required quality level of higher education provision”;
- “Loyalty and trust of stakeholders to the university”;
- “Ability to ensure a living wage for the university staff”;
- “Need to evacuate the university”;
- “Possibility of obtaining scholarships for students from EU universities”.

For the indicators requiring ranking by indicator value, a tare on the following five-point scale was used: 1 (Low); 2 (Rather low); 3 (Medium); 4 (Rather high); 5 (High). This group of indicators includes:

- “Security of higher education provision”;
- “Quality of higher education provision in the context of war”;
- “Costs of relocating the university”;
- “Costs of providing higher education services related to distance working conditions, martial law”.

The methodology has a number of steps and can be divided into two parts (Figure 1).

Figure 1. Building an optimal system to arrange higher education provision under martial law

Model (M.1):

Mathematical modelling of higher education services clustered according to the level of social responsibility achieved under martial law

Step 1. Factor analysis of indicators for clustering higher education services	$M1_{F_i} = \sum_{i=1}^m F_i$ m – the number of key factors of higher education services in war situations $F_i = \frac{1}{\text{Expl.}F_i} \times \sum (a_{ij} \times X_{ij})$ $\text{Expl.}F_i$ – factor load of the i -th factor; a_{ij} – indicator value X_{ij} ; X_{ij} – ij -th indicator.
Step 2. Cluster analysis of indicators of social responsibility of higher education services in the context of war	Making indicators dimensionless: $z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j}$ Minimizing the standard deviation from the cluster center: $\min [\sum_{i=1}^k \sum x(j) \in S_j \ x^{(j)} - \mu\ ^2]$ where $x^{(j)} \in R^n$; $\mu_i \in R^n$; μ_i – cluster centroid R .

Model (M.2):

Mathematical modeling to optimise the provision of higher education under martial law

Step 1. Identification of indicators-activators of the level of social responsibility of higher education services in the context of war	The dendrogram is based on $\mu_i = \frac{1}{S_i} \sum_{x^{(j)} \in S_i} x^{(j)}$ where the cluster centres are recalculated: $\mu_i^{\text{step } t} = \mu_i^{\text{step } t+1}$ $\text{step } t$ – previous iteration, $\text{step } t+1$ – current iteration	
Step 2. Building a model for optimising the provision of higher education in a war environment	The maximum problem $f_1(x) = x_1 + x_2 + \dots + x_n \rightarrow \max$ $a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n \leq 1$ $a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n \leq 1$ $a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n \leq 1$ $x_i \geq 0, (i = 1, 2, \dots, n)$	The minimum problem $f_2(y) = y_1 + y_2 + \dots + y_m \rightarrow \min$ $b_{11}y_1 + b_{12}y_2 + \dots + b_{m1}y_m \leq 1$ $b_{21}y_1 + b_{22}y_2 + \dots + b_{m2}y_m \leq 1$ $b_{1n}y_1 + b_{2n}y_2 + \dots + b_{mn}y_m \leq 1$ $y_j \geq 0, (j = 1, 2, \dots, m)$
Step 3. Building an optimal system of higher education provision in war settings using the matrix method	The matrix shows the maximum value of the quality indicator for higher education on the OX axis and the minimum value of the process cost indicator on the OY axis. Indicator value for each cluster: $d_i = \exp[-\exp(-f_i)]$, where f_i – a standardized value for the strength of the impact of the activator indicator on shaping higher education service delivery in a war context.	

The first model (M.1) represents the clustering of higher education services according to the level of social responsibility achieved under martial law; the second model (M.2) is the mathematical modelling of the optimised provision of higher education under martial law.

4. Empirical results

Building a model for optimising the provision of higher education services by universities under martial law

The results obtained from the factor analysis of the social responsibility level seen in the higher education provision process under martial law are shown in Table 3.

Table 3. Results of factor analysis of indicators of socially responsible higher education processes under martial law (STATISTICA 10 listing)

Variable	Factor Loadings (Unrotated) (data) Extraction: Principal components (Marked loadings are >0,700000)	
	Factor 1	Factor 2
X ₁₁	0,947528	0,136939
X ₁₂	0,967737	0,179234
X ₁₃	0,964241	0,213981
X ₁₄	0,924994	0,295035
X ₁₅	0,948388	0,242523
X ₂₁	-0,226765	-0,234214
X ₂₂	0,296315	0,741028
X ₂₃	0,478221	0,557436
X ₂₄	0,543605	0,782692
X ₂₅	0,257035	0,185595
Expl.Var	5,248632	1,804293
Prp.Totl	0,524863	0,180429

It may be concluded from Table 3 that 7 of the 10 initial indicators influence the educational process management, namely all 5 indicators of social responsibility seen in the arranging of the educational process and 2 indicators of financial support of the process arrangement.

The results of the cluster analysis of higher education services according to the achieved level of social responsibility under martial law are shown in Figure 2.

With reference to Figure 2, according to the level of social responsibility seen in the arranging of the process of higher education provision under war conditions, all the territories of Ukraine were conditionally divided into 6 clusters. The first cluster includes universities in two territories (Table 4). The universities in this cluster are practically unable to provide higher education services due to either partial occupation of the territory or the destruction of their infrastructure, with an acute need for their evacuation and for students to seek opportunities to study in other universities, including EU countries. These are universities in the Donetsk and Luhansk regions.

Figure 2. Results of the cluster analysis of higher education services listed by level of social responsibility under martial law

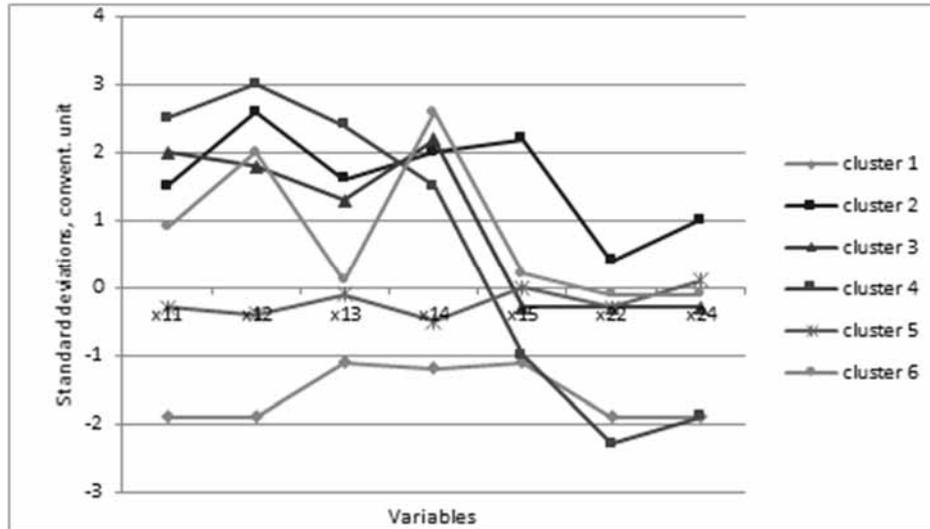


Table 4. Member of cluster number 1 (Data) and distances from respective cluster center (cluster contains 2 cases)

Territory designation	Distance
T5	42498.50
T10	42498.50

The second cluster includes 7 territories (Table 5). Universities in this cluster are able to render higher education services at a sufficiently high level. There is no need for evacuation due to the proximity to the borders with EU countries, and there is no need for students to seek scholarships from EU universities to continue their education. This refers to universities in Lviv, Transcarpathian, Chernivtsi, Ivano-Frankivsk, Volyn, Rivne, and Ternopil regions.

Table 5. Member of cluster number 2 (Data) and distances from respective cluster centre (cluster contains 7 cases)

Territory designation	Distance
T3	41753.37
T4	63385.22
T6	43660.66
T7	64022.66
T13	41092.58
T16	48878.08
T22	58989.92

The third and fourth clusters each include one territory. Kyiv’s universities are in the third cluster, characterised by a high level of educational services and stable financial and logistics

systems. The fourth cluster includes universities in the Kharkiv region. The system of higher education provision is disrupted by the destruction of buildings and the flight of students and teachers. The fifth cluster includes 10 territories (Table 6). These are Dnipro, Zaporizhzhia, Cherkasy, Kirovograd, Mykolayiv, Odessa, Poltava, Sumy, Kherson, Chernihiv regions. Universities in these territories are placed in a rather precarious situation, as there is a high probability of evacuation of the universities, most of the students and teachers have been forced to evacuate, and arranging of the educational process is troublesome.

Table 6. Member of cluster number 5 (Data) and distances from respective cluster centre (cluster contains 10 cases)

Territory designation	Distance
T1	71093.40
T9	54320.09
T12	74096.78
T14	34944.56
T15	19654.88
T17	35077.18
T18	53264.77
T20	50732.63
T21	24598.43
T23	39132.25

The sixth cluster includes four territories (Table 7). These are universities in Ternopil, Khmelnytsk, Zhitomir, and Vinnytsia regions. According to Figure 2, the universities in this cluster are able to provide higher education services at a high level (indicator value x12), the level of information and communication technology provision meets the required quality of higher education provision (indicator value x14), the security of higher education provision (indicator value x11) is at a high level. The value of indicator x11 indicates that there is no need to evacuate these universities (mainly due to their territorial location in the centre of Ukraine). The high level of these indicators indicates that these universities are able to provide a sufficiently high level of social responsibility both to the students (safety and reliability of educational services) and to the teachers (teachers receive a stable salary).

Table 7. Member of cluster number 6 (Data) and distances from respective cluster centre (cluster contains 4 cases)

Territory designation	Distance
T11	40220.75
T19	52693.36
T24	15579.71
T25	34349.82

Preliminary testing of the proposed model relied on the data from open Internet sources, official data of MESU, and processing of data of the online survey of higher education stakeholders conducted as a Google table using the STATISTICA 13 program. As a result, a model for optimising the arranging of higher education provision under martial law was derived based on the principles of maximisation. This means that its solution is at the saddle point for each group of higher education institutions in a particular cluster. The quality and

social responsibility of the provision of educational services is maximised, while the cost of providing them is minimised. Putting this another way, the maximisation function was constructed on the basis of the data in Table 3. It reflects most of the educational processes - the variance value is 52.49% using Eq. 1.

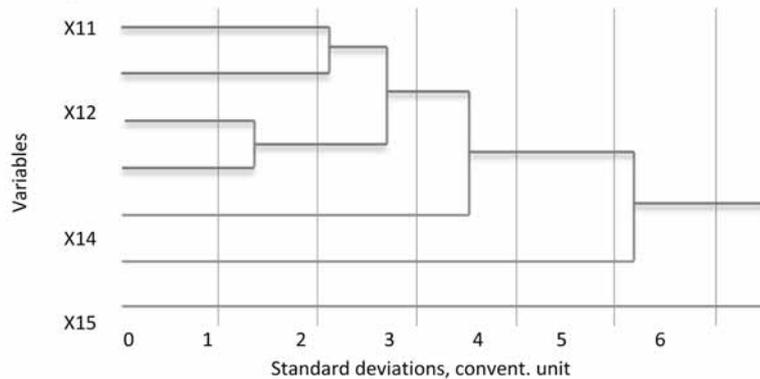
$$f_{1(x)} = \frac{1}{5,248} \times (0,948x_{11} + 0,968x_{12} + 0,964x_{13} + 0,925x_{14} + 0,948x_{15}) \rightarrow \max \quad (1)$$

The minimisation function reflects the ability to minimise the costs of providing educational processes - the variance is 18.04% using Eq. 2.

$$f_{2(x)} = \frac{1}{1,8} \times (0,741x_{22} + 0,783x_{24}) \rightarrow \min \quad (2)$$

The results of the identification of indicators-activators of social responsibility of higher education services in the context of war by means of a dendrogram are presented in Figure 3.

Figure 3. Dendrogram of identification of indicators-activators of social responsibility of higher education services in war situations (STATISTICA 13 listing)

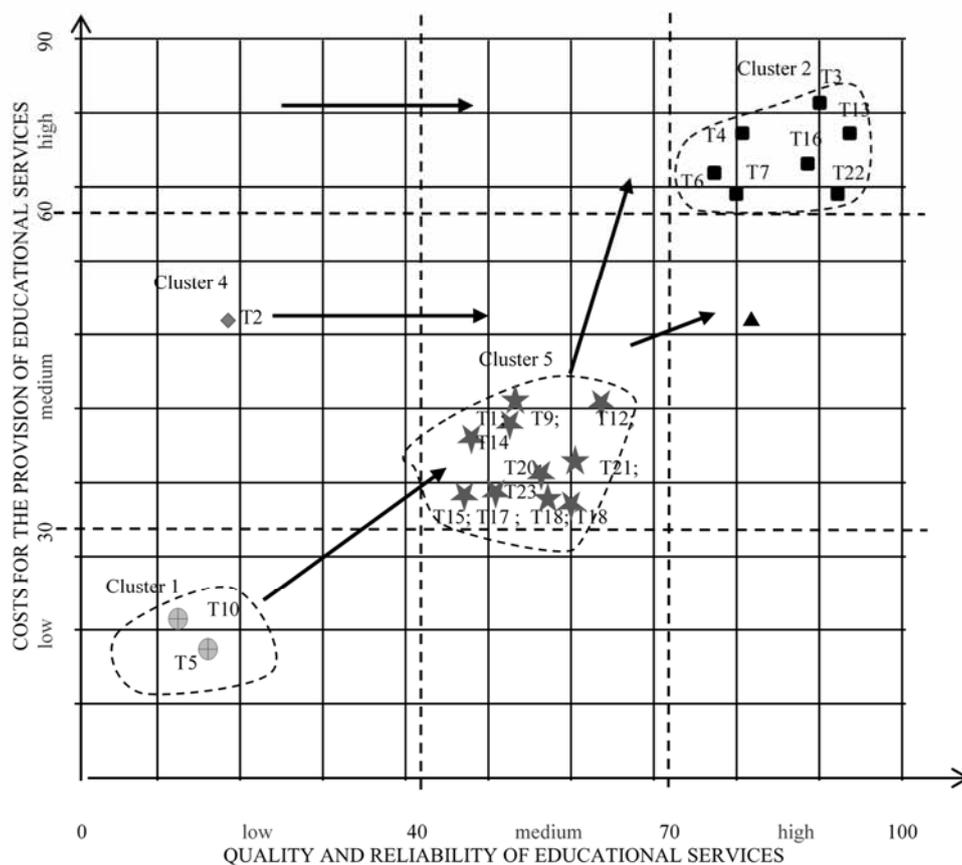


These dendrograms allow for the visualisation and identification of activator indicators of social responsibility of higher education services in war situations.

The first model (M.1) can be used as a tool for clustering higher education services in war. This model continues the theoretical developments presented by Sultana, 2012, Tight, 2015, Van Rooij, 2012, Ganushchak-Yefimenko et al., 2017, and Zhuravka et al., 2021 in key aspects.

The use of the methodological components of the second model made it possible to construct a matrix of exit strategies from crisis situations, maintaining the level of social responsibility achieved and the quality of educational services provided by higher education institutions under martial law (Figure 4).

Figure 4
Matrix of university exit strategies, maintaining the achieved level of social responsibility and the quality of educational services provided by higher education institutions under martial law



Thus, the views outlined by Abou El-Seoud et al., 2014, Babu et al., 2018, and Bezhovski et al., 2016 as for indicator x13 Internet Accessibility being the most significant in the organisation of higher education service delivery in crisis conditions are confirmed. In other words, the named indicator is the driver of this process in order to ensure the management of educational services in war conditions.

In order to build a matrix to optimise the system of provision of educational services in conditions of war, it is proposed to place a driver indicator for minimising logistical costs on the axis of EI. As shown in Fig. 4, this driver is indicator x22 Need to evacuate the university. This assessment refutes the views cited by Beaudoin, 2016 and Bernard et al., 2009 that indicator x25 Costs of providing educational services related to distance working conditions,

martial law can be an activator indicator for reducing costs of providing higher education services in crisis or martial law situations. Nor are the views presented by Brennan, 2018 and Corbett, 2014 that indicator x14 Compliance of information and communication technology with the required level of quality of higher education services may be a driver of this process. In doing so, the opinion presented by Evans, 2010 is supported. Indeed, the strength of the influence of indicators x12 Quality of higher education services under war conditions and x15 Loyalty, trust of stakeholders to a given university, firstly, does not exceed 10-15 percent of the total assessment of the provision of the educational process under war conditions; secondly, it reflects the essence of stakeholders' trust in the higher education system under these conditions in general. The strength of the influence of the activator indicators in the crisis exit strategy development matrix is not equal. Indeed, x11 Security of provision of higher education services simultaneously with ensuring the necessary level of their quality as drivers of the provision of educational processes is almost three times as significant as drivers of expenditure. This confirms the views cited by Green et al., 2010 and Hladchenko, 2020. And the role of indicator x21 Ability to provide living wages to university staff as a possible driver of social responsibility of teachers to stakeholders confirms the point stated in Islam et al., 2021.

Figure 4 shows that the integral indicator on the axis OX “Quality and reliability of educational services” reflects the qualitative component of social responsibility for the provision of educational services. The integral index on the axis “Costs for the provision of educational services” reflects the resource provision of support for social responsibility for the provision of educational services. Both axes visualise the division into 3 gradations: low; medium; high. The 9 quadrants in the matrix field clearly reflect the situation of universities at the current point in time. The arrows indicate the direction and options for exiting or improving the situation of socially responsible educational services.

Thus, as universities in cluster 1 are in the quadrant of low level of social responsibility and quality of educational services provision, it could be recommended for them to evacuate the universities or, if this is not possible, to search for student academic mobility options in EU or Ukrainian universities.

Universities in cluster number 2 are in the quadrant of high social responsibility and quality of educational provision. Therefore, a retention strategy can be recommended for them.

Universities in the Kyiv region cluster number 3 are in the quadrant of high quality of educational services provision and medium level of social responsibility. Therefore, a retention strategy can be recommended for them to maintain the achieved positions of quality of service provision and, at the same time, to increase the level of social responsibility both to students and to teachers.

Universities in cluster 4 (Kharkiv region) found themselves in the medium-quality quadrant of educational service provision, as they were able to convert almost all universities to distance education. At the same time, the threat of university evacuation remains high. Therefore, it is recommended for universities in this region to continue enhancing social responsibility by combining different forms of educational provision.

Universities in cluster 5 (Dnipro, Zaporizhzhia, Kirovograd, Mykolaiv, Odessa, Poltava, Sumy, Kherson, Cherkassy, Chernigov regions) are in the quadrant corresponding to the medium level of quality and social responsibility. This is due to the fact that the organisation of educational process is difficult, so the quality of educational services is at an average level. For this quadrant it is recommended to improve the organisation of the educational process.

Universities in cluster 6 (universities in Donetsk and Luhansk oblasts) are in the quadrant with a low level of quality and social responsibility of the services provided. This is due to the fact that they are practically unable to provide higher education services due to either partial occupation of the territory or due to the destruction of their infrastructure, with a high need for their evacuation and for students to seek opportunities to study in other universities, including EU countries.

Testing of the proposed model (M.2) for optimising the provision of higher education under martial law suggests that the basic assumptions of the model are correct. In order to compare the results obtained by Jegede, 1994, it is necessary to test the model to predict the feasibility of practical strategies for optimising the delivery of educational services. What is meant here is an urgent need for the further re-study in this area. This is especially true as hostilities are ongoing and the stressful effects of war will be felt for a long time to come. Therefore, the proposed models will need to be tested again, taking into account the ongoing changes in the country's higher education system as a whole. At the same time, one should consider a number of limitations. For instance, to find the most effective solutions to optimise service provision not only for the higher education system, but also for all other levels of education, especially when it comes to hybrid educational information technologies. This will provide means for testing the point of view on the possibility of scenario behaviour in such a situation suggested in Kolodiziev et al., 2014. Consequently, to obtain more comprehensive results of the impact of the educational service delivery process on all spheres of society, increasing its social responsibility, on the one hand, the scope and tools of the study should be expanded, and on the other hand, the set of model indicators could be expanded.

5. Concluding Remarks

The article proposes a new scientific and practical approach to enhance the social responsibility of higher education process management under wartime conditions. The methodology consists of the consecutive use of two models. The first model allows the clustering of higher education services by the achieved level of social responsibility under wartime conditions. It consists of two consecutive actions, namely factor analysis of educational services to identify drivers and cluster analysis of higher education services by the achieved level of social responsibility. The first iteration of the second model is the construction of a dendrogram. Its visualisation provides means for identifying complementary sets of driver indicators of arranging the educational process.

The research and testing of the developed models allow us to state that the aim of the article has been achieved. Namely, the use of the developed approach makes it possible to optimise the system of higher education service provision in terms of quality and social responsibility under martial law.

The proposed models have been preliminarily tested on the basis of open Internet sources, official data of MESU, and processing of data obtained from the online survey of higher education stakeholders conducted in the form of a Google table. This allowed ranking of all territories of Ukraine by the level of security, quality of higher education services, and costs of their provision on the principles of social responsibility, in particular, to identify points of growth, stabilisation, and degradation. The use of the dendrogram made it possible to identify activator indicators of quality, security of higher education services, and costs of their provision under martial law. It is assumed that 7 of the 10 indicators affect the provision of the educational process. The deactivator indicators were not included in the model. At the same time, the drivers of quality and accessibility of educational services are almost three times more significant than the drivers of logistical costs. A clear differentiation of all indicators into activators/deactivators would allow higher education institutions (HEIs) in Ukraine to develop a long-term strategy and short-term measures to increase the level of social responsibility to all categories of stakeholders. Consequently, an urgent question is whether HEIs will be able to continue using these models to increase the level of social and technical accountability of higher education provision to all stakeholders. This will enable HEIs to maintain and develop their key competitive advantages when operating under martial law.

The use of the developed methodology of identifying driver indicators, and building a matrix of logistic strategies for exiting crisis situations with their help will increase stakeholder loyalty by 13%; improve the quality and reliability of educational services by 10%; identify points of growth and stabilisation by at least 15-20%. Clustering the logistics of educational services according to the achieved level of social responsibility under martial law revealed 6 clusters. The system of higher education services, depending on the level of social responsibility of universities under martial law, was optimised using two functions, namely maximising the quality and safety of the educational process and minimising the cost of providing educational services.

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