SCIENCE AND EDUCATION FOR SUSTAINABLE DEVELOPMENT

Monograph

Katowice 2022

Science and education

for sustainable development

Edited by Aleksander Ostenda

and Valentyna Smachylo

Series of monographs Faculty

of Architecture, Civil Engineering

and Applied Arts

University of Technology, Katowice

Monograph 50

Publishing House of University of Technology, Katowice, 2022

Series of monographs Faculty of Architecture, Civil Engineering and Applied Arts, University of Technology, Katowice

Monograph · 50

The authors bear full responsible for the text, data, quotations and illustrations

ISBN 978 – 83 – 963977 – 2 – 0
DOI:10.54264/M005

Editorial compilation
Publishing House of University of Technology, Katowice
43 Rolna str. 43 40-555 Katowice, Poland
tel. 32 202 50 34, fax: 32 252 28 75

TABLE OF CONTENTS:

Preface 7

Part 1. Financial and Economic Principles of Sustainable Development 8

1.1. Marketing analysis of the state and prospects of the development of the organic fertilizers market in Ukraine 8
1.2. Analysis of the impact of macroeconomic indicators on tax and fiscal policy indicators in Slovakia 15
1.3. Digital visual fatigue: methods for diagnosing monitoring, and effectively preventing development 23
1.4. Strategic directions of development of the tourist industry of Ukraine in the conditions of European integration 28
1.5. Government funding as a determinant of education quality 35
1.6. Evolution of logistics concept in the context of cross-functional interaction with marketing 40
1.7. Analysis of chains of container transportation supply management in international logistics 50
1.8. 30 years without the soviet union. what belarus economy became 57
1.9. Formation of competitive price as a factor of strengthening the export potential of the enterprise 64
1.10. Assessment of trends in the reform of the medical industry of Ukraine in the conditions of european integration 78
1.11. Approaches to critical infrastructure resilience 87
1.12. The main directions of strategic management of the enterprise in the conditions of sustainable development 96
1.13. Digital development of regions of Ukraine in the context of SDG achievement 104
1.14. Food safety marking system 112
1.15. Measures to combat economically motivated food fraud 121
1.16. Priority directions of reform solidarity pension system to ensure sustainable development in Ukraine 128
1.17. Outsourcing as a way of organization accounting services market (dynamic aspect) 136
1.18. Formation of fiscal space for economic growth in the medium and long term 143
1.19. Economic aspects of using nanomaterials for the space industry 149
1.20. The importance of port management in ensuring the sustainable development of the transport system 157
1.21. Deferred demand as an engine for the development of post-covid tourism in the world and in Ukraine 170
1.22. Economic and statistical approaches to determining the influence of prices and margins on business structure's profit formation 179

Part 2. Innovative and Information Technologies in Education: Applied Aspects 191

2.1. A new educational environment formation in the conditions of digitalization of society 191
2.2. Innovative trends in higher education in the context of sustainable development (on the example of physics and technics disciplines) 203
2.3. The development of professional and mathematical competence of university students in modern technical preparation 210

2.4. Carpathian school: non-formal educational centre on the way to european integration 219
2.5. The formation of the synergetic style of thinking of students in the physics studying process 225
2.6. Means of expressing emotions of fear: psychological influence on the reader (on the material of the stort novel by N. Gogol) 234
2.7. Features of formation of humanitarian integrated knowledge of future information technology specialists 240
2.8. The role and place of coaching in reforming and development university science 248
2.9. Project based learning as an integral part of education for sustainable development 254
2.10. Interdisciplinary links implementation in the education bachelors training by cloud resources means 263
2.11. Theoretical and practical aspects of the implementation of lifelong learning in modern society 269
2.12. Implementation of e-learning on operational flight control 276
2.13. Interdisciplinary approach to training of wood proceeding specialists for formation of sustainable development of Ukrainian industry 282
2.14. Development of advertising skills in graphic editors 288
2.15. Use of flipped classroom technology in teaching foreign languages at higher education institutions 304
2.16. Methodological support for musical art masters' training 310
2.17. Modern domestic education in the context of philosophical reflection 317
2.18. Application of art therapy in correctional work with children with speech disorders 324
2.19. Deep psychoiogikal aspect of the influence of mental trauma on the survival of the subject 334
2.20. Innovative orientation of the educational process of higher education institutions of Ukraine 340
2.21. Information and communication technologies in the system of formation of experience of educational and research activities 345
2.22. Education as a strategic national priority in the conditions of informatization of society 353
2.23. Computerization of learning in the context of the modern paradigm of education 359
2.24. Trends of higher education development in Ukraine in the context of digitalization 371
2.25. Mental development of older preschool children in the process of acquainting them with nature 376
2.26. Training of the future masters of preschool education for realization of educational tasks for sustainable development 383
2.27. Features of professional training of skilled workers for car service in the labor market 389
2.28. Art-therapeutic aspects of choreographic art and its relationship with the creative abilities of junior schoolchildren 406
2.29. Use of interactive teaching methods in the professional training of future flight operator managers 414
2.30. Methodological aspects of case technology implementation in the pre-service teachers' training 421
2.31. The image of the author through the prism of the autobiographical novel "Experience" by Martin Amis 431
2.32. Organization of management of educational process and introduction of innovative technologies of training in higher school as a component of quality of education 444
2.33. Androgogical competence as the basis of professionalization of teaching personnel of modern higher education institutions 450

2.34. Social governance and development of social skills of future specialists: terminological analysis 467
2.35. Efficiency of educational work of rescuers with primary schoolchildren in the conditions of formation of a new state standard of primary education 474
2.36. Pedagogical conditions for implementing the method of adaptive physical education for children with intellectual disorders 478
2.37. Development of observation as a condition for the formation of natural science competence of primary school students 489
2.38. Pedagogical conditions for the effective implementation of a creative approach to the development of primary school children by means of nature in the context of educational innovations 501
2.39. Distance learning in neurology in terms of COVID-19 pandemic: advantages and disadvantages 510
2.40. Leading types of preschoolers' activities: interdisciplinary approach 514
2.41. Cloud technologies of education 529
2.42. Introduction of information technologies in the system of management of institutions of general secondary education 536
2.43. Peculiarities of morphofunctional condition and physical health of pupils of 1-4 grades of rural school 554
2.44. Diagnostics of the interpretive skills formation of future musical art specialists 565
2.45. The role of the science to ensure the sustainable development: international imperatives and national practices 572
2.46. Education as a necessary condition for achieving sustainable development 583
2.47. Formation peculiarities of future teachers' conflictological culture in the higher educational system 589
2.48. Distance education in a pandemic as a basis for sustainable development 608
2.49. Project activity as an effective form of research-oriented learning in scientific lyceums 616
2.50. Relationship between oedipal dependence and the formation of the personal problem of the subject 621
2.51. Study of the formation of vibration signs during the operation of the movement mechanism during the use of the running wheels of the modernized design 627
2.52. The phenomenon of conventional of values, its deep psychological essence 640
2.53. Subject's conditional values of interpersonal interaction 646
2.54. Integration as one of the pedagogical conditions for the formation of speech competence of future bachelors in document science 652
2.55. Application of project activity in professional training of choreographic specialists 658
2.56. Plagiat as an element of negative and criticality of such education 665
2.57. Technical and vocational education for sustainable society development: historical experience of Ukraine 675
2.58. Education in the interests of sustainable development and social responsibility of the university 682
2.59. Methodical aspects of learning educational disciplines (subjects) during the mixed form of education on the patterns of phytopathology as one of them 689
2.60. Social workers professional competence as a result of the educational process and as a prerequisite for effective professional activity 693
2.61. Using of cloud technologies in laboratory classes under quarantine restrictions 702
2.62. Features of soft skills development children of senior preschool age in play activity: theoretical and methodological aspect 708
2.63. STEAM-design in the creation of interdisciplinary educational environment for future teachers of secondary and professional school 719

Part 3. Socio-Humanitarian Aspects of Sustainable Development 730

3.1. Formation of future musical art teachers’ research competence during their study at pedagogical higher education institutions 730
3.2. Scientific research for the challenges of the future in the field of employment 737
3.3. Organizational culture transformation in the process of intelligent industrial enterprise forming in the context of digitalization of the economy 743
3.4. Evaluation of effectiveness of piggyback traffic within the national network of international transport corridors of Ukraine 753
3.5. Peculiarities of globalization processes transformation and prospects of research activity in the context of sustainable development strategy of society 763
3.6. The use of modern physical culture and health technologies in the physical education of higher education 773
3.7. The experience of providing social support by the Municipal Institution of the Sumy Regional Council – Sumy Regional Center of Complex Rehabilitation for Children and Persons with Disability 781
3.8. Adaptation of tree plants of the genus Tilia L. to the conditions of the urban environment 789
3.9. Psychophysiology of coloristics in the life of primary school children with psychophysical development disorders 797
3.10. Culture as a factor of sustainable development 804
3.11. Integration-disintegration processes of the psychology of personality in its deep knowledge 812
3.12. Higher education establishment as a subject of forming ideas of family roles among the student youth 819
3.13. Transpositional paradigm of the sentence in Ukrainian 825
3.14. The state of development of the concept of sustainable development in the public administration science in Ukraine 833
3.15. Status of vaccination and awareness of student youth about vaccines in the convention of the COVID-19 pandemic 842
3.16. Sustainable development of the city: managerial and social aspects 847
3.17. Preschool education: art and IT 859
3.18. Conceptual aspects of pedagogical modeling of cognitive motivation of junior schoolchildren 867
3.19. Digital volunteering as a means of sustainable development 881
3.20. The role of humanitarian policy in ensuring sustainable society development 888
3.21. Spesial aspects of creative skills formation as a component of professional competence of future teachers of physical education 894
3.22. Formation of technologies of communicative competence of students of economic specialties 900
3.23. Stagnation of multimedia content in the modern day of preschool education 906
3.24. Tendencies implementation of professional-pedagogical training of teachers in terms of educational services quality management 912

Part 4. Technical Solutions to Ensure Sustainable Development 920

4.1. Experimental research and numerical analysis of a typical automobile spring 920
4.2. Risk assessment of emergencies during forced ventilation petroleum products tanks 930
4.3. Economic aspects of choosing types of fire tanks for equipment of fire and rescue departments 940
4.4. Prospects for using acoustic radiation during combustion for early ignition detection seat in the storage zones of petroleum products 950
4.5. Analysis of the technical condition of the park of port cranes in the sea ports of Ukraine 956
Annotation 964
About the authors 994

PREFACE

The increasing role of education and science in modern society has caused changes in its understanding. Modern education becomes a condition for the country's development, a guarantor of its security, determines the level of the economy. Thus, education and science for sustainable development must function as a direct generator of new socio-economic life and produce social, environmental, and economic changes towards sustainable development.

One of the preconditions for achieving a sustainable development of society is science and education, which are also the most important tools for effective governance, sound decision-making, democracy. At all stages of development and implementation of the concept of sustainable development – from clarifying the need, formulating ideas to practical implementation, it requires a strong, deep, and extensive scientific and theoretical basis and the widest possible educational and explanatory work.

In addition, one of the main tools for sustainable development should be the close interaction of education with science.

Therefore, the problem of supporting the development of education and science is deeply social and is one of the priorities of social development, which is directly related to the system of national interests, improving the quality of life and national security.

The monographic research presents the scientific works of the team of authors that reveal different directions and aspects of science and education in providing sustainable development. These are: 1) Financial and Economic Principles of Sustainable Development; 2) Innovative and Information Technologies in Education: Applied Aspects; 3) Socio-Humanitarian Aspects of Sustainable Development; 4) Technical Solutions to Ensure Sustainable Development.

The first section of the monograph deals with questions of economic development, modelling, and analysis of microeconomic and macro-economic processes.

The second section of the monograph outlines the role of education and science in sustainable development. The authors considered innovative technologies and ICT in the educational and scientific system.

The third section of the monograph "Socio-Humanitarian Aspects of Sustainable Development" looks at the environmental, linguistic, psychological, cultural, and art-therapeutic aspects of the development of society.

The fourth section of the monograph focuses on technical solutions for securing and protecting sustainable development.

The team of authors hopes that the monograph contains useful research results that are relevant for scientists, students and anyone interested in various aspects of education and science, given their significance in various areas of public life.

Editors

3.4. EVALUATION OF EFFECTIVENESS OF PIGGYBACK TRAFFIC WITHIN THE NATIONAL NETWORK OF INTERNATIONAL TRANSPORT CORRIDORS OF UKRAINE

The advantageous geographical location of Ukraine fosters the development of innovative technologies related to cargo transportation. Prospects for sustainable development of transport in Europe are associated with stimulating the combined (intermodal) transportations[1375]. The main task of intermodal transport is qualitative and timely cargo transportation while providing economic efficiency and favorable conditions for carriers. Such transportations preserve the environment from pollution and harmful factors, which is one of the topical problems today.

The purpose of the article is to study the development of intermodal transportations in the transport market of Ukraine, identifying advantages and disadvantages of such transportations, determination of savings between piggyback and direct automobile transportations.

The urgency of the problem. Railway transport is an integral part of the production and transport logistic chain, charged with the task to achieve the highest economic efficiency in the implementation of processes of production and cargo transportation.

An analysis of the development of progressive technologies for cargo transportation shows that the advantage should be given to highly profitable transportation, including mixed with multiple modes of transport. Given the competition in the transport market, increasing the economic efficiency of railway transportation is a determining factor in the financial stability of the railways' operation in Ukraine.

Many scientists, scholars devote much attention to the issue of intermodal transportations, especially today when piggyback transportations are considered as one of the effective areas in expanding transport services. Special mention should go to such famous scientists: Y. S. Aloshynskyi, T. V. Butko, M. I. Danko, Y. V. Domin, A. M. Kotenko, H. M. Kirpa, A. O. Kovalov, D. V. Lomotko, H. I. Nesterenko, and others[1376].

Considering the specifics of combined transportations, it is necessary to distinguish cargo traffic flows from the total volume that are suitable for piggyback transportations to perform

[1375] Gapanovich V. A. (2012). On the organization of piggyback transportation on the "Space 1520". Railway Transport. No 6. P. 30-35.

Kotenko A. M., Shilaev P. S. (2009) Intermodal Transportation: Prospects of the Development. Collected Scientific Works of the Ukrainian State University of Railway Transport. Iss. 54. P. 31-36.

[1376] Bech P. V., Nesterenko G. I., Muzykina S. I., Lashkov O. V., Muzykin M. I. (2015). Ways to Increase Competitiveness of Railway Transport in Modern Conditions. Science and Transport Progress. No. 5 (59). P. 25-39.

Bech P. V., Lashkov O. V., Muzykin M. I., Nesterenko H. I., Avramenko S. I. (2017) The Management of Freight Traffic and Railcar Traffic on the Railway. Visnik of the Volodymyr Dahl East Ukrainian National University. No. 3 (233). P. 22-30.

Gapanovich V. A. (2012). On the organization of piggyback transportation on the "Space 1520". Railway Transport. No 6. P. 30-35.

Kotenko A. M., Shilaev P. S. (2009) Intermodal Transportation: Prospects of the Development. Collected Scientific Works of the Ukrainian State University of Railway Transport. Iss. 54. P. 31-36.

Muzykina H. I., Savenko A. S., Bech P. V. (2005) The problem of Cargo Transportation Management in Conditions of Impact of Economic Factors. Bulletin of the Academy of Customs Service of Ukraine. No. 1 (25). P. 51-57.

Nesterenko H. I., Kirichenko H. I., Ozerova O. O. (2012) Technological standards for the operations logistics center rail. Visnik of the Volodymyr Dahl East Ukrainian National University. No. 6 (177), Part 1. P. 169-173.

Savenko A. S., Muzykina H. I., Bech P. V. (2005) Economic Efficiency of Container Transportation by Railway Transport. Bulletin of Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan. Iss. 9. P. 226-228.

Nesterenko H., Muzykin M., Avramenko S. (2019) Practical Aspects of Improving the Operation Interaction of the Station and Sidings. Transport Problems: VIII International Symposium of Young Researchers, Katowice. P. 927-934.

Butko T., Muzykin M., Prokhorchenko A., Nesterenko H., Prokhorchenko H. (2019) Determining the rational motion intensity of train traffic flows on the railway corridors with account for balance of expenses on traction resources and cargo owners. Transport and Telecommunication Journal. 20 (3). P. 215-228.

calculations. According to foreign sources, the part of combined transportations in total volume should be up to 10%[1377].

The foreign experience shows that in the organization of combined automobile-railway transportations, the average length of the distance of dispatch L_a by automobile ways should not be more than 20% of the cargo distance of dispatch by railway L_r. During the research, the length of the distance of dispatch was taken in some range – from 5 up to 30%, namely

$$L_a = r \cdot L_r,$$

where r – a part of haul distance by automobile ways from haul distance by railway (it is accepted 0.05-0.30).

In previous studies[1378], it is given that both the traffic handling cost, and the reduced specific costs show results similar in meaning. However, in determining the rational distance of piggyback transportation, it is very difficult to give preference to any one criterion. This is because the increase in the running speed of piggyback trains leads to a reduction in the travel time, but at the same time, as calculations[1379] prove, the mechanical work of locomotive, the costs of electricity (fuel) and the costs of a train mileage increase. All this is reflected in the current operating costs and the traffic handling cost does not decrease with rising speed but remains practically constant. On the other hand, with increasing speed, the cargo delivery time decrease, the rotation of cars, locomotive and, respectively, the reduced specific costs decrease.

Therefore, when establishing a rational distance of piggyback transportation, the entire system of criteria is considered, and first of all – monetary ones.

As a result of approximation, it has been established that reduced specific costs that are attributed to 1 ton of cargo are well approximated at automobile and railway transportations by a linear function

$$П_т(а) = а_1 + b_1 \cdot L; \qquad П_т(з) = а_2 + b_2 \cdot L,$$

The traffic handling cost and reduced specific costs, attributed to 10 *ton-km*, are expressed by hyperbolic dependence

$$П_{ткм}(а) = а_3 + b_3 \cdot L; \qquad П_{ткм}(з) = а_4 + b_4 \cdot L,$$

After approximation of the calculated data at a running speed of 50 km/h, the formulas have been obtained in Table 1.

Table 1. Types of empirical functions accepted in the study

Values of indices	Types of functions for transport	
	Automobile	Railway
$П_т$, UAH/t	к (0.66+ 0.04071 · L)	к (6.37 + 0,003954 · L)
$П_{ткм}$, UAH/10ткм	к (40.72+ 654.61 · L)	к (3.95 + 6362,5 · L)
C_e, UAH/10ткм	к (28.72 + 225.05 · L)	к (1.79+ 5333,0 · L)

1377 Butko T., Muzykin M., Prokhorchenko A., Nesterenko H., Prokhorchenko H. (2019) Determining the rational motion intensity of train traffic flows on the railway corridors with account for balance of expenses on traction resources and cargo owners. Transport and Telecommunication Journal. 20 (3). P. 215-228.

1378 Bech P. V., Nesterenko G. I., Muzykina S. I., Lashkov O. V., Muzykin M. I. (2015). Ways to Increase Competitiveness of Railway Transport in Modern Conditions. Science and Transport Progress. No. 5 (59). P. 25-39.

Bech P. V., Lashkov O. V., Muzykin M. I., Nesterenko H. I., Avramenko S. I. (2017) The Management of Freight Traffic and Railcar Traffic on the Railway. Visnik of the Volodymyr Dahl East Ukrainian National University. No. 3 (233). P. 22-30.

1379 Muzykina H. I., Savenko A. S., Bech P. V. (2005) The problem of Cargo Transportation Management in Conditions of Impact of Economic Factors. Bulletin of the Academy of Customs Service of Ukraine. No. 1 (25). P. 51-57.

Similar empirical dependencies have been obtained for other values of movement speed.

Determination of rational distance of combined transportations. To determine the rational distance of transportations, an analysis by some criteria was carried out:

- According to the criterion of reduced specific costs of 1 ton of cargo. In this case, the equation of reduced specific costs in the automobile and combined transportation can be represented in the form

$$a1 + b1 \cdot L = (a1 + b1 \cdot r \cdot L) + [a2 + b2 \cdot (1\text{-}r) \cdot L]$$

In the above expression: leftward – costs at the direct automobile transportation; rightward: the first addition – costs of cargo transportation from the shipper to the departure station and from the destination station to the cargo receiver, the second addition – the costs at transportation by railway.

After conversion, we obtain a formula for determining the rational distance of piggyback transportations:

$$L = \frac{\mathrm{a}_2}{(b_1 - b_2)\cdot(1-r)} \qquad (1)$$

This formula works at r > 0.

The values of the rational distance of transportations by criterion Пт are calculated by the formula (1) for various source data are in Table 2.

Table 2. The rational distance of transportations by criterion Пт, km.

Speed of motor vehicles, km/h	Characteristics of the standard area	Specific weight of the automobile haul distance		
		0.1	0.2	0.3
40	light-load	178	200	229
50		193	217	248
60		204	229	262
40	heavy-load	186	209	239
50		201	226	259
60		213	239	274

- according to the criterion of specific costs for 10 *ton-km* and the traffic handling cost. In this case, the equation of reduced specific costs at the automobile and combined transportations can be represented in the form

$$a_3 + b_3 / L = (a_3 + b_3 \cdot r \cdot L) + [a_4 + b_4 \cdot (1 - r) \cdot L] \qquad (2)$$

In the above expression (2): leftward – costs at the automobile transportation; rightward – costs at the combined transportation. After conversion, we obtain:

$$L = \frac{b_4}{(a_3 - a_3) \cdot (1 - r)}$$

The values of the rational distance of transportation by criteria $П_{ткм}$ and C_e are calculated for various source data and given in Table 3.

Data analysis of Tables 2, 3 shows that the value of the rational distance of transportations by two criteria – specif reduced costs that are attributed to 1 ton of cargo and to 10 *ton-km* coincide, and at the ratio between the length of the automobile haul distance to the distance of transportation by railway $L_a/L_з$ = 0.2 are in the range of 200-240 *km* depending on section load and movement speed.

Table 3. The rational distance of transportations by criteria $П_{mкм}$ and C_e, km

Speed of a motor vehicle, km/hour	Criterion	Specific weight of the automobile haul distance		
		0.1	0.2	0.3
40	C_e	178	200	229
50		192	216	247
60		203	229	261
40	$П_{ткм}$	212	238	272
50		220	248	283
60		226	254	290

With a decrease in the speed of cargo supply to the departure station and pickup of cargo from the destination station by automobile transport, the rational distance of transportation by railway decreases up to 200 *km* at a running speed of motor vehicles of 40 *km/h* and increases up to 230 *km* at a speed of 60 *km/h* (Fig. 1).

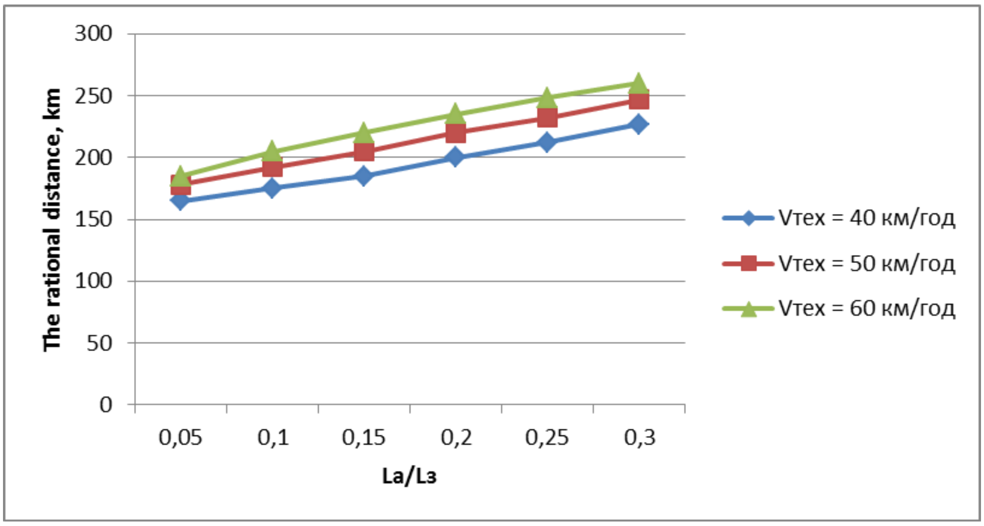

Fig. 1. Dependence of rational distance of transportation from the ratio of transportation lengths by automobile and railway transport by specific reduced costs

By the traffic handling cost, the rational distance is within 240-255 *km* for a relatively easy section by the plan and the profile (Fig. 2).

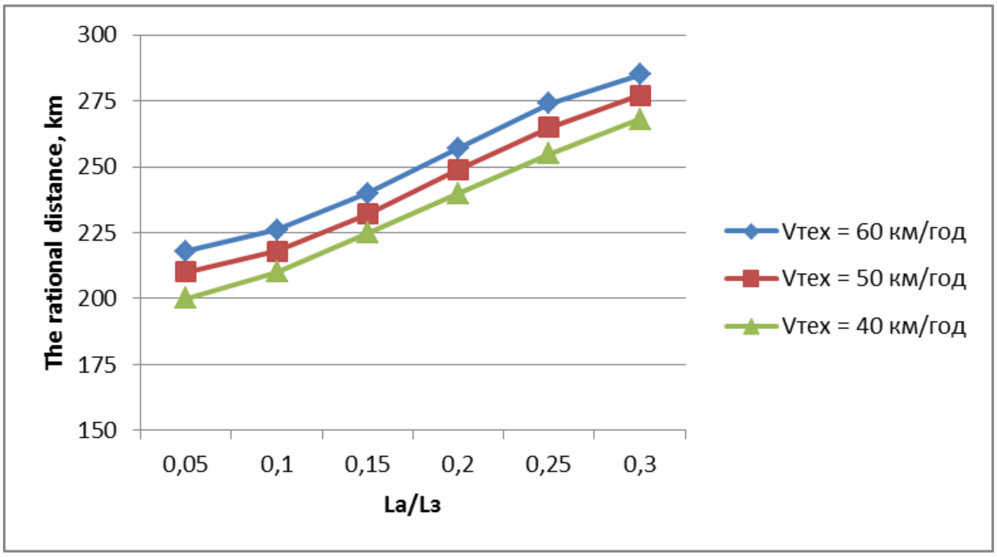

Fig. 2. Dependence of the rational distance of transportation from the ratio of transportation lengths by automobile transport and railways by the traffic handling cost

Thus, it can be assumed that piggyback traffic is effective practically by all economic criteria at the distance of cargo transportation of more than 250 *km*.

Table 4 shows the specific costs (for 1 ton of cargo) to perform the entire complex of driving, loading/unloading, and other transactions with piggyback trains. For clarity, expenses in a percentage ratio are presented in Figure 3.

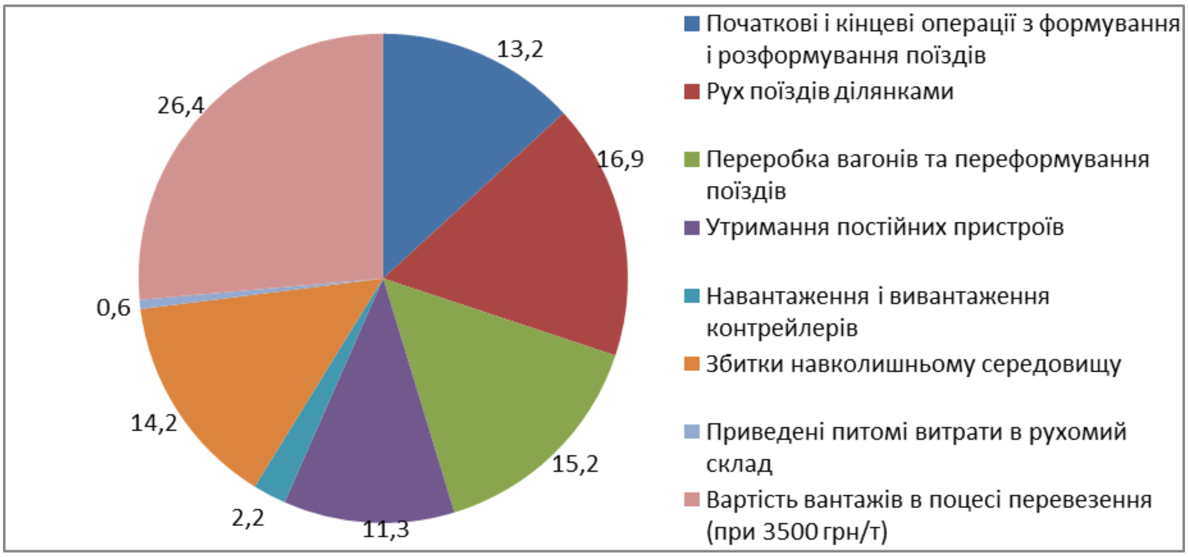

Fig. 3. The diagram of costs for cargo transportation by railways

The reduced specific costs ($П_т$, *UAH/t*) and the traffic handling cost (C_e *UAH/10 ton-km*) for the Uzhhorod – Kharkiv direction are compared in Tables 5 and 6 at the following source data:

- the annual volume of transportations – 1,27 *million* tons;
- the average tariff distance by railways – 1160 *km*;
- the average tariff distance by roads – 1400 *km*;
- the average length of the distance of dispatch by roads – 240 *km*.

The calculations are performed for different load-carrying capacities of motor vehicles and different costs of cargo that are being carried.

Table 4. Impact of basic factors on the reduced specific costs ($П_m$, $П_{ткм}$) and traffic handling cost C_e

Factors naming	Specific costs		Amendments, %	Conforming amendments, %	
	UAH/10ткм	%		$П_т$, $П_{ткм}$	%
Marshaling and breaking up of a trains	4.80	16.9	10	1.69	2.80
Movement by sections	4.31	15.2	10	1.52	2.51
Shunting operations of cars and remarshaling of trains	3.22	11.3	10	1.13	1.87
Maintenance of fixed equipment	0.63	2.2	10	0.22	0.35
Loading and unloading of contrailers/piggybacks and their storage	4.02	14.2	10	1.42	2.33
Environmental destruction	0.18	0.6	10	0.06	0.12
The reduced capital investments in to rolling stock	7.51	26.4	10	2.64	4.37
The cost of cargo in the transportation process	3.75	13.2	10	1.32	2.19

Table 7 shows the results for the average load section, with a running speed of 50 *km/h*, cargo capacity of semitrailers of 26 *tons*, the cost of cargo is 10 *thousand UAH/t* and the length of the distance of dispatch by roads is 17% from the distance of transportation.

Table 5. Comparison of reduced specific costs at the direct automobile and combined transportations

Cargo capacity of semitrailer, *t*	Price for 1 t of cargo, *thousands UAH*	Direct automobile transportations $П_т(a)$	Automobile-railway transportations			$П_т(a)$ - $П_т(c)$
			Automobile haul distance $П_т(dis)$	Railway transportations $П_т(r)$	Combined transportations $П_т(c)$	
20	100	207.52	37.03	35.54	35.85	5.79
	300	237.76	42.95	54.62	52.17	4.56
26	100	171.57	30.59	32.57	32.15	5.34
	300	201.81	36.47	51.60	48.42	4.17
32	100	149.07	29.86	30.63	43.70	3.41
	300	179.34	32.45	49.72	46.09	3.89

Table 6. Comparison of traffic handling cost at the direct automobile and combined transportations.

Cargo capacity of semitrailer, *t*	Direct automobile transportations $C_e(a)$	Automobile-railway transportations			$C_e(a)$ - $C_e(c)$
		Automobile haul distance $C_e(dis)$	Railway transportations $C_.(r)$	Combined transportations $C_,(c)$	
20	121.80	125.30	17.71	40.30	3.02
26	101.15	103.95	17.36	35.54	2.85
32	88.20	90.30	17.05	32.43	2.72

Table 7. Prime cost (C_e, грн/10 ton-km) at automobile and piggyback transportatioins as a function from a distance

Distance of transportations, *km*	Criterion	Direct automobile transportations	Automobile-railway transportations		
			Automobile haul distance	Railway transportations	Combined transportations
400	$П_т$	59.28	11.97	30.71	27.52
	$П_{ткм}$	148.30	176.05	92.47	106.68
	C_e	102.60	112.35	44.87	56.34
700	$П_т$	102.03	19.39	36.89	33.92
	$П_{ткм}$	145.60	161.35	63.60	80.22
	C_e	101.85	107.10	28.25	41.65
1000	$П_т$	151.90	27.93	44.03	41.30
	$П_{ткм}$	144.55	155.05	50.61	69.36
	C_e	101.50	105.00	20.79	35.11
1400	$П_т$	201.81	36.47	51.56	49.00
	$П_{ткм}$	144.20	151.90	44.45	62.72
	Ce	101.15	103.95	17.29	32.03

For the accepted source data, the difference between reduced specific costs and the prime cost at automobile and piggyback transportations as a function from a distance (Table 7) can be represented by the following dependencies:

$$\Delta П_т = 0.121 \cdot L - 16{,}6$$

$$\Delta П_{ткм} = 97.44 - \frac{22351}{L}$$

$$C_e = 78.47 - \frac{12845}{L}$$

From the first expression, we see that piggyback transportations for the accepted source data are effective at distances more than 140 *km*, from the second one – at 230 *km*, and from the third expression – at 160 *km*. Thus, with some margin, it can be assumed that piggyback transportations are effective at a distance of more than 250-300 *km*.

Determination of costs related to piggyback transportations on the railway transport. Costs related to the piggyback transportations on the railway transport are determined by formulas.

The exploitation costs are determined by the formula:

$$E = E_{mov} + E_{in}^{loc} + E_{in},$$

where E_{mov} – costs associated with train movement, *thousands* UAH;

E_{in} – costs associated with the inactivity of piggyback train at technical stations without changing the locomotive, *thousands* UAH;

E_{in}^{loc} – costs associated with the inactivity of piggyback train at technical stations with changing the locomotive and locomotive crews, *thousands* UAH.

Costs associated with train movement are determined by formula:

$$E_{mov} = 365 \cdot \sum NL \cdot e_{t\text{-}km},$$

where $\sum NL$ is the sum of a train-kilometer;

$e_{t\text{-}km}$ – the cost of one train-kilometer, *thousands* UAH.

Costs associated with the inactivity of piggyback train at technical stations with changing the locomotive and locomotive crews are determined by the formula:

$$E_{in}^{loc} = 365 \cdot \sum NH \cdot e_{t\text{-}hour},$$

where $\sum NH$ is the total train-kilometer of the inactivity at technical stations with train locomotive;

$e_{t\text{-}hour}$ – cost of one train-hour of inactivity with locomotive, UAH.

Costs associated with the inactivity of piggyback train at technical stations without changing the locomotive are determined by the formula:

$$E_{in} = 365 \cdot \sum mt \cdot e_{car\text{-}hour},$$

where $\sum mt$ is the total train-hours of the inactivity at technical stations without locomotives;

$e_{car\text{-}hour}$ is the cost of one car-hour of inactivity without the locomotive, UAH.

Capital investments are determined in to locomotive and a car fleets. It is necessary to take into account the number of locomotives, which is necessary for the piggyback train motion throughout the entire direction. When calculating capital investments, we also take into consideration the cost of rolling stock of the piggyback train, which consists of 22 platforms and 2 compartment cars.

Capital investments in to the locomotive fleet are determined by the formula:

$$C_l = \frac{\sum NL}{24 V_{sec}} \cdot P_l,$$

where V_{sec} – section speed at the sections of direction, *km/hour*;

P_l is the price of a train locomotive, UAH.

Capital investments in to the locomotive fleet are determined by the formula:

$$C_i = n_{pl} \cdot P_{pl} + n_{com} \cdot P_{com},$$

where n_{pl}, n_{com} – a number of platforms and compartment cars respectively;

P_{pl}, P_{com} – the price of a platform and a compartment car respectively.

To perform calculations of costs that are related to the movement of trains, we determine the price of the 1st train-kilometer for each of the sections, which is determined by the method of expenditure rates. The calculated scheme of the 1st train-kilometer is given in Table 8.

In accordance with the recommendations we accept in the calculation:

- β_y, β_y' – 0.02 and 0.01 respectively;
- κ_2 – the coefficient includes an additional time that a locomotive crew spends in the main depot and in points of circulation (it is accepted $\kappa_2 = 1.5$);
- a_e electricity consumption for the measuring set "10000 *ton-km* gross load" (it is accepted a_e = 110 kilowatt-hours);
- a_e^e – the rate of electricity consumption per 1 km of mileage (it is accepted a_e^e = 25 kilowatt-hours).

Table 8. The costing scheme associated with 1 train-kilometer when servicing the train by one locomotive

Measuring set	Expense of the measuring set	Cost rate, *UAH*
Car-kilometers	t	1.597
Car-hours	t / V_{sec}	73.437
Locomotive-kilometers	$1 + \beta_y$	62.105
Locomotive-hours	$1 / V_{sec} + \beta_y$	95.460
Crew-hours	$1 / V_{sec} * \kappa_2$	607.613
Ton-kilometers gross load of cars and locomotive	$Q_{gr} + P_l$	0.017
Electricity consumption	$\frac{а_з * Q_{бр}}{10000} + а_э^э * \beta y'$	10

We determine the schedule speed for calculating the each section of the direction.

An example of calculating the price for 1 train-kilometer for the Fastov – Darnytsia section is shown in Table 9.

Table 9. Calculating the price for 1 train-kilometer at the Fastov – Darnytsia section

Measuring set	Calculation	Expense of the measuring set	Cost rate, *UAH*	Cost for 1 train-kilometer,*UAH*
Car-kilometers	t	24	1.597	38.328
Car-hours	t / V_{sec}	0.51	73.437	37.453
Locomotive-kilometers	$1 + \beta_y$	1.02	62.105	63.347
Locomotive-hours	$1 / V_{sec} + \beta_y$	0.041	95.460	3.914
Brigade-hours of locomotive crews	$1 / V_{sec} * \kappa_2$	0.032	607.631	19.444
Ton-kilometers of gross load for cars and locomotive	$Q_{gr} + P_l$	1928	0.017	32.776
Electricity consumption	$\frac{а_з * Q_{бр}}{10000} + а_э^э * \beta y'$	17.516	10	175.16
Total				370.422

The final results of calculating the reduced costs that are associated with piggyback transportations are given in Table 10.

An analysis for the technology of piggyback transportation allows to structure the following advantages:

1). With an increase in the distance, the traffic handling cost by railways dramatically decreases, since the costs for the initial-end operations are distributed to a large amount of tons-kilometer work. On the road transport is, on the contrary, the costs for the initial-end operations at long distances are no longer affect the prime cost since significant costs are exactly on the transportation process;

2). During combined transportation, diesel fuel consumption decreases. The monetary evaluation shows that fuel costs at direct automobile transportations are higher than at combined ones;

3). The use of piggyback transportation reduces the delivery time of cargo;

4). According to forecasts, the volume of automobile carriages by some transport corridors over the subsequent years will increase almost twice as compared with the current ones, which will increase the issue of exhaust gases and noise pollution. Therefore, the prospect of piggyback distribution is closely linked to the need for unloading automobile roads and environmental protection;

5). Piggyback transportations slow down the wear of highways, reduce the level of destructive impact on the road surface due to the heavyweight cars isolated from the traffic flow;

6). It is possible to determine such an effect as maintaining the driver's productivity of mechanical transport vehicle (MTV), who can spend most of the route in comfortable conditions of the passenger car;

7). It should be noted a decrease in the number and simplification of customs operations while performing the transportation by the piggyback train.

Table 10. Calculation of the reduced costs for piggyback transportations in directions

Section	Illichivsk – Zhmerynka	Mohilev – Fastov	Fastov – Nizhyn	Nizhyn – Khutor – Mykhailivskyi
Costs for 1 train *–km, UAH*	354	517	370	354
Length, *km*	611.4	320	189.9	227.3
Movement time, *hours*	10.05	4.4	3.64	3.39
Schedule speed, *km/hour*	60.8	72.7	52.2	67.1
Exploitation costs, *thousand UAH*	3959.7	1227.6	2025.2	2343.3
Losses associated with the inactivity of trains without locomotives, *thousand UAH*	308.8	64.98	449.44	3029.7
Capital investments in to locomotive and car fleets	11967.2	8128.1	2484.3	22208.9
Costs associated with the inactivity of trains without locomotives, *thousand UAH*	—	—	—	44.407
Total exploitation costs, *thousands UAH*	4268.5	1292.58	2474.7	5417.4
Reduced costs, *thousand UAH*	5704.6	2267.9	3062.3	8082.5

Conclusions. Having analyzed the current state of combined transportation and its main disadvantages, we found that the main obstacle to the widespread use of such cargo transportation in Ukraine is the practical lack of proper legislative regulatory framework and too high transportation tariffs. As a result of conducted calculations, some trains, train tonnage, several bogies, a method of placing on the platform were analysed. The dimensions of the platform-mounted train allow its transportation on the railways.

From the research, it follows that both by the traffic handling cost, and reduced specific costs practically identical results were obtained. Analysing piggyback transportation, it has been determined that passing of trains on sections with a light load profile and plan, compared to heavy, will reduce the specific reduced costs and traffic handling cost up to 4-6%.

Performing loading and unloading of contrailers/piggybacks in these calculations is provided with truck-tractors and end / edging metal or reinforced-concrete approach ramp. Such expenses are up to 15% of total costs. They can be reduced if performing loads and unloads of platforms with a high platform on the stub ended track. So, a reduction in the cost of loading-unloading operations by 1/3 will decrease the reduced specific costs and traffic handling cost from 6% to 10%.

For the intensification of transportation in the international communication, the issue of introducing fixed piggyback train formation into rotation is considered (on heavy section is of 20 platforms, on others is of 40 platforms). The introduction of such trains will lead to accelerating the cargo delivery, reducing the rotation of platforms, increasing the efficiency of transport services.

In the study, the authors performed a comparison of the options for cargo delivery, which proves that piggyback transportation at distances over 250-300 km is more effective.

It is determined that at the direct automobile transportations of cargoes for long-distance by semi-trailers in comparison with the combined ones, the harmful factor is five times higher, and energy costs increase by three times.

The use of cargoes of semi-trailers of high load-carrying capacity for transportation will reduce the need for rolling stock (both automobile and railway) and reduce the specific reduced costs and traffic handling cost by about 10%.

Also, it should be noted that in addition to unloading of the automobile ways and improving their condition, in addition to reducing the probability of road vehicle accidents, in addition to improving the environmental situation, the combined transportations also have advantages:

- it is the more rational use of fuel;
- it is resource conservation of expensive automotive equipment;
- it is reducing the dependence of transport processes from weather conditions, especially in the winter on heavy sections of the route.

References

1. Bech P. V., Lashkov O. V., Muzykin M. I., Nesterenko H. I., Avramenko S. I. (2017) The Management of Freight Traffic and Railcar Traffic on the Railway. *Visnik of the Volodymyr Dahl East Ukrainian National University*. No. 3 (233). P. 22-30.

2. Bech P. V., Nesterenko G. I., Muzykina S. I., Lashkov O. V., Muzykin M. I. (2015). Ways to Increase Competitiveness of Railway Transport in Modern Conditions. *Science and Transport Progress*. No. 5 (59). P. 25-39. doi: 10.15802/stp2015/55349.

3. Butko T., Muzykin M., Prokhorchenko A., Nesterenko H., Prokhorchenko H. (2019) Determining the rational motion intensity of train traffic flows on the railway corridors with account for balance of expenses on traction resources and cargo owners. *Transport and Telecommunication Journal*. 20 (3). P. 215-228.

4. Gapanovich V. A. (2012). On the organization of piggyback transportation on the "Space 1520". *Railway Transport*. No 6. P. 30-35.

5. Kotenko A. M., Shilaev P. S. (2009) Intermodal Transportation: Prospects of the Development. *Collected Scientific Works of the Ukrainian State University of Railway Transport*. Iss. 54. P. 31-36.

6. Muzykina H. I., Savenko A. S., Bech P. V. (2005) The problem of Cargo Transportation Management in Conditions of Impact of Economic Factors. *Bulletin of the Academy of Customs Service of Ukraine*. No. 1 (25). P. 51-57.

7. Nesterenko H. I., Kirichenko H. I., Ozerova O. O. (2012) Technological standards for the operations logistics center rail. *Visnik of the Volodymyr Dahl East Ukrainian National University*. No. 6 (177), Part 1. P. 169-173.

8. Nesterenko H., Muzykin M., Avramenko S. (2019) Practical Aspects of Improving the Operation Interaction of the Station and Sidings. *Transport Problems: VIII International Symposium of Young Researchers*, Katowice. P. 927-934.

9. Savenko A. S., Muzykina H. I., Bech P. V. (2005) Economic Efficiency of Container Transportation by Railway Transport. *Bulletin of Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan*. Iss. 9. P. 226-228.

2.58. Lesya Chervona – PhD in Philosophy, Senior Researcher Fellov, Institute of Higher Education, National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine

Nataliia Lakusha – PhD in Philosophy, Associate Professor, Kyiv National University of Construction and Architecture, Kyiv, Ukraine

2.59. Tatiana Cherkis – Senior Lecturer, State Biotechnological University of Kharkiv, Kharkiv, Ukraine

2.60. Ruslan Chubuk – PhD of Pedagogical Sciences, Associate Professor, Petro Mohyla Black Sea National University, Mykolaiv, Ukraine

2.61. Serhii Shevchenko – Doctor of Technical Sciences, Associate Professor, State Biotechnological University, Kharkiv, Ukraine

Anastasiia Suska – Doctor in Economics, Associate Professor, State Biotechnological University, Kharkiv, Ukraine

Vasyl Diakonov – PhD of Technical Sciences, Associate Professor, State Biotechnological University, Kharkiv, Ukraine

2.62. Oleksandra Shykyrynska – PhD of Pedagogical Sciences, Associate Professor, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Vinnytsia, Ukraine

Olga Kanarova – PhD of Pedagogical Sciences, Associate Professor, Bogdan Khmelnytsky Melitopol State Pedagogical University, Melitopol, Ukraine

Lily Medun – Speech Therapist, Children's center "LOGOCLUB", Vinnytsia, Ukraine

2.63. Iryna Shymkova – PhD of Pedagogical Sciences, Senior Lecturer, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Vinnytsia, Ukraine

Svitlana Tsvilyk – PhD of Pedagogical Sciences, Associate Professor, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Vinnytsia, Ukraine

Vitalii Hlukhaniuk – PhD of Pedagogical Sciences, Associate Professor, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Vinnytsia, Ukraine

Part 3. SOCIO-HUMANITARIAN ASPECTS OF SUSTAINABLE DEVELOPMENT

3.1. Iryna Chystiakova – PhD of Pedagogical Sciences, Associate Professor, Sumy State Pedagogical University named after A. S. Makarenko, Sumy, Ukraine

3.2. Liudmyla Deineko – Doctor in Economics, Professor, Institute for Economics and Forecasting of NAS of Ukraine, Kyiv, Ukraine

Ella Sheludko – PhD in Economics, Senior Researcher, Institute for Economics and Forecasting of NAS of Ukraine, Kyiv, Ukraine

Mariia Zavgorodnia – PhD in Economics, Research Officer, Institute for Economics and Forecasting of NAS of Ukraine, Kyiv, Ukraine

3.3. Hanna Doroshuk – Doctor in Economics, Associate Professor, Odesa Polytechnic National University, Odesa, Ukraine

3.4. Mykhailo Muzykin – PhD of Technical Sciences, Senior Lecturer, Ukrainian State University of Science and Technology, Dnipro, Ukraine

Halyna Nesterenko – PhD of Technical Sciences, Associate Professor, Ukrainian State University of Science and Technology, Dnipro, Ukraine

Albina Kuzmenko – PhD of Technical Sciences, Associate Professor, University of Customs and Finance, Dnipro, Ukraine

3.5. Viktor Zinchenko – Doctor in Philosophy, Senior Researcher Fellov, Institute of Higher Education of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine

Oleksandr Polishchuk – Doctor in Philosophy, Professor, Khmelnytskyi Humanitarian Pedagogical Academy, Khmelnytskyi, Ukraine

Volodymyr Kaluha – Doctor in Philosophy, Associate Professor, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine

3.6. Olha Anastasova – PhD of Pedagogical Sciences, Associate Professor, Berdyansk State Pedagogical University, Berdyansk, Ukraine

3.7. Natalia Bezdidko – Methodist Center, Municipal Institution of Sumy Regional Council – Sumy Regional Center for Comprehensive Rehabilitation for Children and Persons with Disabilities, Sumy, Ukraine

3.8. Andrey Bulat – PhD of Agricultural Sciences, Associate Professor, State Biotechnological University, Kharkiv, Ukraine

3.9. Olha Vovchenko – Doctor in Psychology, Senior Researcher, Mykola Yarmachenko Institute of Special Pedagogy and Psychology of the National Academy of Pedagogical Sciences of Ukraine, Kyiv, Ukraine

3.10. Nataliia Grynchuk – PhD in Economics, Associate Professor, Municipal Research Institution «City Development Institute», Kyiv, Ukraine

Mykhaylo Baginskyy – Chief Researcher, Municipal Research Institution «City Development Institute», Kyiv, Ukraine

3.11. Ilona Kalashnik – PhD in Psychology, Associate Professor, Bohdan Khmelnytsky National University of Cherkasy, Cherkasy, Ukraine

3.12. Dariia Karpova – PhD in Psychology, Senior Lecturer, Khmelnytsky National University, Khmelnytsky, Ukraine

3.13. Olena Kuts – PhD in Philology, Associate Professor, Dragomanov National Pedagogical University, Kyiv, Ukraine

3.14. Mykola Lakhyzha – Doctor of Science in Public Administration, Professor, Institute for Personal Training of the State Employment Service of Ukraine, Kyiv, Ukraine

Tamara Lozynska – Doctor of Science in Public Administration, Professor, Poltava State Agrarian University, Poltava, Ukraine

Oleksandr Dorofyeyev – Doctor in Economics, Associate Professor, Poltava State Agrarian University, Poltava, Ukraine

3.15. Jevgenija Nevedomsjka – PhD of Pedagogical Sciences, Associate Professor, Borys Grinchenko Kyiv University, Kyiv, Ukraine