

The object of this study is a system of incentives aimed at activating the processes to manage construction waste formed during hostilities.

The problem being solved is to form incentives for the growth of economic interest in construction waste management.

The structural and functional readiness of the economy for the management of waste generated as a result of hostilities is investigated. It was revealed that 60 % of the participants in the waste management system are microenterprises with a profitability of 0.2 %. The level of construction waste disposal and the level of its reuse are estimated. Forecasts of the behavior of methods of waste management in the absence of changes in state policy have been made. Based on the use of forecasting methods, a trend of increasing the amount of waste dumped at landfills has been identified. The directions of state influence on the formation of economic incentives for the processing of construction waste have been proposed.

A special feature of the study's results is that the inconsistency of existing incentives with the needs of participants in the field of waste management has been investigated. The problem with the activities of small enterprises is the demand for performance, at the formation of which government efforts should be directed. Distinctive features of the results are that they solve the problems of achieving a balance of economic interests of participants in the management of construction waste generated during the war. The area of practical use of the obtained results is the system of state and local management of waste handling activities

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1. Introduction

Construction waste is an integral attribute of the economic development of any country and the indicator of waste generation is a kind of indicator of its economic activity. In the waste management system, special attention is paid not to the process of formation but to waste management, as a way of waste disposal, which affects the resource, environmental, and social components of the economic system of each country.

Depending on the structure of the industry, the share of construction waste ranges from 60 % of the total industrial waste (Germany) to 2.5 % (Ukraine). On average, only a

third of construction waste in the world is recycled. Modern technological solutions make it possible to process up to 60 % of construction waste, which indicates the potential use of construction waste to replace the resources of mineral raw materials.

Timber can be reused for landscape design, compost, or building articles. Wood chips are used to make wooden concrete. Restored wooden components can be reused to preserve the original appearance of buildings. Steel is the most recyclable material in Europe with an average processing factor of 50 %. Glass fragments are recycled into fiberglass or used for pavement. Marble floors and facing sheets, which are used to restore marble and facing materials, are also widely used.

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CREATING INCENTIVES FOR MANAGING CONSTRUCTION WASTE GENERATED DURING THE WAR

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Plumbing units are crushed and used for the production of inexpensive cements. Crushed stone containing masonry elements and concrete is processed to produce recycled aggregates suitable for plastering. Broken bricks are used as a building fill or aggregate for non-structural concrete.

The low level of waste recycling increases environmental risks, reduces the resource potential of the economy. Thus, the production of concrete from waste components reduces carbon dioxide emissions into the atmosphere compared to the production of cement from mineral raw materials, respectively reducing the risk of global warming. After all, carbon dioxide is considered the main cause of global warming.

In all countries of the world, the choice of a technique to manage construction waste is made within the framework of the established state policy of construction waste management. Certain norms, rules and forms of control have determined the economic, environmental, and social effectiveness of construction waste management in each of the countries of the world.

In the event of unpredictable accumulation of construction waste as a result of hostilities, the role of the state in determining a technique of handling such waste and the share of its processing is growing. Scientific research on this topic is important because it summarizes the experience of building waste management, analyzes the practice of using mechanisms and tools to influence the volumes and methods of managing construction waste. The results of such studies are needed in practice because the construction waste management policy is based on them. The need to change approaches to such a policy is caused by the need to start the processes of revitalizing the reconstruction of the destroyed infrastructure, increasing the level of employment of the population, and reducing the level of environmental hazards. This is evidenced by the experience of European countries after the Second World War, as well as Bosnia, Albania, Lebanon, Israel, and Palestine.

2. Literature review and problem statement

The problem of waste management generated during the construction and demolition of buildings has formed a separate area of scientific research aimed at solving it. The relevance of research on construction waste management is evidenced by an interdisciplinary scientific interest in solving its problems. The generalization of scientific papers made it possible to single out three aggregated areas of research on construction waste management: technological, environmental, and analytical.

The technological direction is mainly aimed at publishing innovative solutions for waste recycling and the possibilities of their use in the production of concrete and asphalt. The environmental direction solves the problem of the impact of the technique of construction waste management on the environment. Analytical studies summarize and compare construction waste management practices in countries around the world, identify factors and analyze the tools of the greatest impact on the effectiveness of such management. The versatility of the tasks that need to be solved in the construction waste management system has necessitated limiting the focus on the analysis of analytical research. In [1], among the main factors influencing the level of construction waste disposal is the lack of modern processing technologies and

a stimulating mechanism for recycling construction waste and control over its use.

The problem of systematic research of the causes of low level of processing of construction waste by country is investigated in [2], which summarizes the problems of the development of the industry for the processing of construction waste and demolition in China. These include the instability of the waste source, lack of subsidies for recycling activities, waste minimization policies, on-site sorting rules, etc.

However, the issues of further development of the construction waste management system remain unresolved. An option to overcome the corresponding difficulties may be a scientific study of the feasibility of developing the structure of participants in the field of construction waste management. In [3], the expediency of increasing the number of participants in the waste management chain through the construction of plants for the processing of construction waste has been economically proven. It was investigated that the efficiency of the construction of such a plant is achieved under the condition of a functioning filler market, an increase in the tariff for the removal of waste to landfills, the formation of state policy, and the strengthening of monitoring and control of waste. Nevertheless, the work presents a generalization of local factors that ensure the efficiency of the operation of waste processing plants.

According to research [4, 5], the effective and sustainable development of the field of construction waste management depends on legislative and informational support, financial support, clear rules for regulating the behavior of market participants. Noting the practical significance of the research results regarding the development of cooperation, integrated waste management [4], the formation of certainty and trust between interested parties [5], the mechanisms of formation of a set of such relations are not defined in the cited works. The role of the state in the management of construction waste is emphasized in study [6], the results of which confirmed the need for legislative incentives. The authors of the study, based on the results of modeling the strategies of behavior of participants in the field of waste management, conclude that it is necessary to execute state management of waste producers and processors. The use of a wide mathematical apparatus provided a generalized result of the study, without determining the structures, tools, features of the state's influence on the sphere of production and processing of construction waste.

The need to form a system of friendly relations between processors and waste suppliers is emphasized in [7]. Based on data modeling, in [7], it is proved that the use of state subsidies can lead both to an increase in the volume of supply of secondary raw materials and to an imbalance in the relationship between the supplier and the processor of waste. The author's conclusion takes into consideration only the information component of ensuring the management of construction waste and does not determine the level of balance between the size of the subsidy and the positive perception of the partner.

Based on the use of the theoretical model of the game between producers and processors, it was determined in work [8] that fines and government incentive mechanisms have a direct impact on the volume of waste recycling. It is proved that the subsidy system is a more effective incentive for the growth of construction waste processing, compared to the administration system in the form of control and fines. It was also concluded that the stability of the relationship

between the supplier and the processor of construction waste depends on the level of GDP. The authors note that the change in the level of GDP changes the strategy of stability of relations between producers and processors of construction waste, but the work does not disclose ways to neutralize the negative impacts on the volume of waste processing.

The impact of tax incentives on the construction waste management system is investigated on the basis of the relationship between the taxation of landfills and the volume of construction waste [9]. The authors concluded that there is no correlation between landfill taxation and waste generation. They also proved that low market readiness for secondary materials, inefficient regulation, poor quality of information support are among the main problems that need to be addressed in the field of construction waste management. The study of the dependence of the impact of taxation on all participants in the waste management system would make it possible to have a complete picture of the impact of tax incentives on waste recycling volumes and to identify neutral participants.

In addition to the reliability of statistical support, the need to form a coordinated and complete information support for construction waste management is emphasized in other studies. The issue of forming information support for construction waste management has been solved by creating integrated databases [10], forming a policy of greater awareness of stakeholders about the circular economy and the quality of the economic justification for management decisions [11]. Noting the importance of the quality and completeness of information support, it was desirable to focus on information predictors for each of the participants in the construction waste management system.

The generalization of the results of scientific research [1–11] led to the conclusion that the task to form an effective mechanism for stimulating the growth of the level of processing of construction waste remains unresolved and requires further research.

Recycling of construction waste demonstrates an insufficient level in almost all countries, regardless of the level of their development. In studies [2, 3, 7–9] it is proved that the level of construction waste disposal is achieved under conditions of favorable legislative regulation, organizational support, introduction of economic incentives.

All authors state the fact of the need for changes in the system of ensuring the management of construction waste but the issues of balancing the economic interests of all stakeholders in the construction waste management system are little studied.

This problem is not solved due to the existence of various economic systems and tools for their regulation. In market economic systems, market incentives are the main regulator of the system of relations between its participants. However, as the research results show [9], even in developed market economies, the area of processing construction waste requires a change in the legislative tools for its regulation.

In addition, most papers reveal the results of studying factors and ways to increase the level of recycling of waste resulting from construction work or the demolition of construction objects. The problem of recycling construction waste is actualized in view of the rapid pace of their accumulation as a result of the destruction of the country's infrastructure during the hostilities. Experience in the management of such waste is fragmented, there is no comprehensive established practice, and the mechanisms and management

chains are only being formed and are not universal either in relation to waste classes or to countries.

One example is the Concept of reconstruction of Warsaw, according to which it was necessary to ensure maximum reuse of unbeaten bricks for the reconstruction of the city and crushed construction waste in the process of concrete production. In the process of rebuilding the city, surviving baths, door handles, handrails were used. Germany also used its model of waste management resulting from the destruction of buildings. This model provided for testing the destruction for the presence of materials suitable for further use. The wreckage consisted of bricks and other building materials such as concrete and lime or cement mortar. The mixture suitable for further use was used to produce low-quality concrete for floor and ceiling slabs, as well as hollow blocks. Measures were taken to avoid the ingress of gypsum mortar or slabs in large quantities into concrete mixes in order to prevent adverse effects of soluble sulfate. It was also forbidden to use organic materials in concrete mixes of the highest quality. In West Germany, after sorting construction waste and isolating residues suitable for further use, construction waste was buried in mounds [12].

Construction waste generated during the fighting in Syria was used to reconstruct cities.

Over the past 30 years, a number of conflicts have taken place in Iraq, resulting in a significant proportion of construction waste. There were various plans for handling them: changing the purpose, selling to developers, or demolition. In 1991 and 2003, weapons with depleted uranium were used in Iraq. According to Iraq's Environment Ministry and radiation protection center, there are hundreds of sites contaminated with nuclear radiation. Accordingly, that made it impossible to use such construction waste.

Israel also used weapons made of enriched uranium. It is believed that these weapons are highly carcinogenic and harmful to the environment. Thus, the surviving components and construction waste after the use of such weapons cannot be reused [13].

In Beijing, construction waste was used to modernize the city. The State Bureau and enterprises were actively engaged in the collection and restoration of materials. In order to monopolize demolition waste, unauthorized collection and sale of materials was prohibited. This mode of disposal of buildings directed most of the usable building materials to state-owned enterprises. Most of the building materials used remained in the urban center. During the reform period (1978–present), on the contrary, peripheral cities and villages became the main consumers of Beijing's demolition waste. In reformed China, demolition waste has become an active part of the urban economy. In the cities there are enterprises that are engaged in the organization of the collection, sorting, and transportation of waste. These enterprises buy used building materials from property owners in the city, help city authorities reduce recycling costs and create jobs [14].

The Palestinian experience of building waste management is also interesting. In addition to concrete, Palestine uses metal residues, surviving remnants of buildings, wood, glass, which has intensified the region's construction industry, created hundreds of jobs and "restarted" the economy. In the management of waste generated as a result of hostilities, Palestine is on the way to analyzing the ways of their processing and reuse in conditions of limited opportunities and real modern experience [15].

Accordingly, addressing this problem requires an analysis of the state of readiness of the country's economy for disposal and the formation of a system of state support for the economic interest of all participants in the construction waste management system. All this suggests that it is expedient to conduct a study on the formation of incentives for the management of construction waste generated as a result of hostilities.

3. The aim and objectives of the study

The aim of this study is to summarize the totality of state and economic tools to stimulate the processing of construction waste, which will allow government agencies to create incentive mechanisms to enhance the disposal of construction waste generated as a result of hostilities.

To accomplish the aim, the following tasks have been set:

- to analyze existing legislative incentives for the growth of construction waste processing at the regional level;
- to analyze the impact of existing incentive mechanism on the effectiveness of activities related to the collection, disposal of waste, and recovery of materials;
- to form a set of means of formation of long chains of management of construction waste formed as a result of hostilities.

4. The study materials and methods

The object of this study is a system of state incentives aimed at activating the processes of management of construction waste formed during the hostilities.

With the help of the state regulation system, it is possible to create incentives to intensify the disposal of construction waste. By forming government incentives, it is possible to influence market demand, and, as a result, the volume of disposal of construction waste, the level of employment, and budget revenues.

The issues of identification of waste generated in the process of human life and the activities of the industrial and agricultural sectors, the service sector are determined in the classifier of waste [16]. Identification of waste generated as a result of unforeseen events in the classifier is defined only in relation to waste generated as a result of man-made disasters (accidents), natural disasters, and phenomena. The main way to handle them, according to the Classifier, is to collect, process, and delete. No technique for waste management formed as a result of hostilities is defined in the current classifier.

Waste classification is a prerequisite for taking a set of management actions to determine the technique of handling each of the selected groups. Waste identification makes it possible to make a set of management decisions to create economic conditions for the realization of the economic interest of all participants in the waste management system. The isolation of waste generated as a result of hostilities will make it possible to legislatively consolidate the way it is handled and organize its use to obtain secondary construction resources, steel, non-ferrous metals, etc.

The Ministry of Environmental Protection and Natural Resources of Ukraine is developing a draft national classifier NK 005:2021 "Waste Classifier", which is planned to be supplemented with the classification of military waste. However, given that the classifier DK 005-96 was applied to the

study period, the statistics of the formation and management of waste were formed according to the codes of this classifier.

To build rational waste management chains, it is worth delimiting the concept of military waste from waste that is formed as a result of war. Military waste is waste generated as a result of ensuring the functioning of all types of military equipment and weapons, as well as waste that arises during their disposal.

Waste generated as a result of war is a combination of different classification groups of waste that are generated as a result of both hostilities and ensuring the functioning of troops. Thus, in the process of war, various groups of waste are formed: construction ruins, household, medical, military waste.

The features that determine the need to isolate construction collapses as a special group of waste are their mixed nature, changes in their primary characteristics, significant pollution, which complicates the use of traditional technologies for their disposal. Such features of these wastes impose certain restrictions on the choice of how to handle them. Thus, as a result of the destruction of the housing stock, masses are formed that combine building materials, waste in the form of household appliances, electronics, glass, textiles, plastic, wood, metal structures, etc. The use of traditional methods of handling them involves the use of sorting operations, which is complicated due to the possible danger, quantity, physical characteristics, level of pollution, labor costs, the need to use special equipment. All this together creates conditions for the inefficiency of sorting them into separate fractions. On the other hand, the formed rubble requires the need for immediate adoption of a way of handling them, since they can pose a danger to the life of the population, have the potential of secondary resources for road and housing construction.

The existing state waste classifier (DK 005-96) provides for the formation of construction waste as a result of construction work, demolition and repair of buildings and structures (code 451) and as a result of man-made disasters (accidents), natural disasters and phenomena (code 459). Analysis of the volumes and dynamics of construction waste generation was carried out according to official statistics of Ukraine [16].

According to the State Statistics Committee of Ukraine [17], in 2018–2020 there was an increase in waste, which constitutes the largest share in the total amount of construction waste generated (Table 1).

The largest share in the total volumes of construction waste generated is mixed waste from construction and demolition of buildings and structures (75 %).

In European statistics, the level of construction and demolition waste disposal is used to assess the level of waste management [18]. In Europe, recycled construction waste is considered to be prepared for reuse, recycled, or subject to disposal of materials, including through backfill operations [18].

In Ukraine, recycling is the use of waste as secondary material or energy resources [19].

According to EU statistics, the level of construction and demolition waste recycling in the EU in 2018 was 90 %, in particular in the Netherlands, Ireland – 100 %, France – 73 %, Norway – 63 %, Poland – 84 %, Germany – 93 % [18].

In Ukraine, the level of recycling of mineral construction waste and demolition of facilities, including mixed construction waste, was 16.7 %, and the level of reuse was 2.1 % (Fig. 1) [17]. The rest of the waste (83.3 %) is placed in specially designated places (landfills).

Table 1

Waste generation by classification groups of the state waste classifier in 2018–2020, tons [17]

Name of waste according to DK 005-96	Year			Share in 2020, %
	2018	2019	2020	
Gravel, crushed stone, sand, dolomite flour, aggregates, gypsum cements, waterproofing mastic, bonding substances damaged, contaminated, or unidentified, their residues that cannot be used for their intended purpose	11730.3	5414.6	27248.0	3.6
Concrete wall products, pillars, concrete tiles are damaged, contaminated, or unidentified, which cannot be used for their intended purpose	5216.9	1613.2	24017.1	3.1
Bricks residue, materials of wall stone	5950.5	1081.7	18423.4	2.4
Mix of building materials and gypsum-based products	4155.2	2962.3	2442.8	0.3
Materials and products related to construction insulating, including cardboards, canvases, mats, plates, damaged, contaminated, or unidentified, their residues that cannot be used for their intended purpose	10298.3	6930.0	2363.1	0.3
Materials and products made of refractories are damaged, contaminated, or unidentified, their residues that cannot be used for their intended purpose	70214.8	80022.1	92669.4	12.1
Mixture of soil and stones	8510.4	8782.5	4329.5	0.6
Reinforced concrete and metal structures and iron and steel parts are damaged (damaged) or unidentified	5783.8	4135.4	9984.9	1.3
Waste mixed construction and demolition of buildings and structures	789243.4	662121.2	577916.5	75.7
Construction products (including repair of buildings and structures, roads, bridges, overpasses, etc.), substandard	2696.3	9898.4	3561.7	0.5
Fragments of damaged or destroyed buildings and structures (including bridges, tunnels, roads, pipelines), communications and power supply systems to be dismantled, processed, and removed	322.9	215.6	884.0	0.1

At the end of 2020, 38921.5 thousand tons of construction waste were placed in landfills [17].

The war on the territory of Ukraine led to an unpredictable increase in the volume of construction waste. As of June 26, 2022, 15 million square meters of housing have been destroyed in Ukraine. The UNOSAT Damage Assessment survey map based on satellite images makes it possible to estimate the amount of damage and the level of destruction [20].

According to the information defined in the National Waste Management Strategy in Ukraine until 2030, an average of 3000 cubic meters of construction and repair waste is generated in Ukraine from one obsolete five-story compartment building. Given the scale of destruction, at the end of June 2022, at least 82,710 billion cubic meters of mixed waste were formed in Ukraine [21].

The ongoing hostilities and the tense situation in the war zone increase the amount of destruction, and, accordingly, the volume of waste.

The above statistics are evidence of the accumulation of construction waste on the territory of Ukraine and are convincing evidence for the need to change state instruments of influence on the formation of the chain of their treatment.

The impact of the existing system of state and economic incentives on the formation of a chain of construction waste management

was assessed according to the statistics of the State Committee of Ukraine in accordance with the 38 code of the Classifier of Types of Economic Activity (CTEA-2010). Code 38 includes three classes: 38.1 (waste collection), 38.2 (the removal and treatment of waste before its disposal), 38.3 (recycling of metal and non-metallic waste and scrap into secondary raw materials) [22].

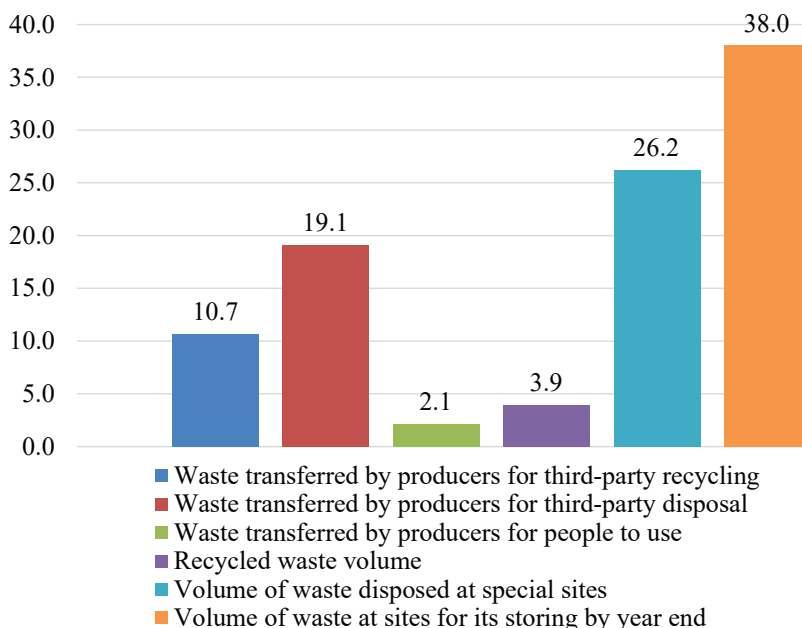


Fig. 1. Management of mineral waste from construction and demolition of facilities, including mixed construction waste, % [17]

5. Results of investigating the influence of incentive mechanisms on the management of construction waste

5.1. Analysis of existing legislative incentives for the growth of construction waste recycling at the regional level

The hostilities exacerbated the problem of building waste management and put the state before the need to take a set of radical actions to create conditions for the implementation of entrepreneurial initiatives to recycle construction waste.

Legislative incentives for participants in the waste management chain are defined in the Law “On Waste”. In particular, the Law provides for the possibility of providing business entities with tax, credit, and other benefits, financing under a state contract, a special regime for stimulating their collection, procurement, and use, etc. [23]. Based on the analysis of the practice of their implementation in the activities of enterprises, it can be stated that the identified legislative possibilities have not been fully implemented and have not ensured an increase in the volume of construction waste disposal.

The Tax Code of Ukraine provides for temporary, until January 1, 2027, exemption from value added tax on transactions for the supply of waste, scrap metals, paper and cardboard for disposal. Taking into consideration the fact that 60 % of small enterprises in the field of waste management are micro enterprises, for them such tax incentives do not create effective tools for intensifying their activities.

There are no other tax exemptions in the legislation.

The main problem of the activities of small businesses is the demand for the results of their activities. A larger share of enterprises operating in the field of waste management specialize in the procurement of scrap metal, wastepaper, and plastic. Demand is the main incentive for the development of any entrepreneurship and for the implementation of any tasks. Only the formation of demand for secondary resources from construction waste can be an effective incentive for its disposal.

As for credit benefits, they are defined in the general programs of state support for the development of entrepreneurship. In particular, under the program “Affordable Loans 5-7-9”, it is envisaged to reduce the interest rate depending on the number of jobs created. The state support system does not provide for separate lending programs for the introduction of innovative technologies for waste treatment and recycling.

Financing of all expenses arising in the subjects of activities related to the collection, disposal of waste, and restoration of building materials is carried out by their owners.

The current legislation does not provide for the provision of a special regime to stimulate the collection and recovery of materials from waste.

5.2. The effectiveness of activities involving the collection, disposal of waste, and recovery of materials

A prerequisite for the formation of mechanisms for stimulating the management of waste generated as a result of hostilities is the analysis of economic achievements of activities related to the collection, treatment, and disposal of waste; restoration of materials (CTEA 38). Such an analysis will make it possible to assess the effectiveness of the impact of the existing system of state regulation on

the volume of construction waste disposal and summarize the structural features of the waste management chain. The assessment will make it possible to identify those activators that meet the interests of participants in the field of construction waste management. Since the statistical information is represented according to the CTEA, and not the Waste Classifier, therefore, the analysis of this section will reflect the impact of incentives on the effectiveness not of individual groups of construction waste but of the entire waste management system.

Assessment of the state of the waste management sector was carried out according to the following criteria: structural changes, the presence of growth, profitability. Structural changes in the field of waste management reflect changes in the structure of participants in this market and make it possible to identify activities with the least economic interest. Growth trends are a sign of the positive impact of the environment on activities. Profitability is an indicator of the balance of economic interests of the state and business in the field of waste management.

In 2020, the total number of enterprises of this type of economic activity was 1621, of which waste collection activities were carried out by 910 enterprises, waste treatment and disposal – 190, restoration of materials – 521 (Table 2).

Table 2
Number of operating enterprises for the collection, treatment, and disposal of waste, material recovery (CTEA 38) [24]

Year	Total	% to the total number of operating enterprises		
		large	medium	small
2010	1969	0.1	12.8	87.1
2011	2104	0.1	12.0	87.9
2012	1749	0.1	11.6	88.3
2013	2009	0.1	8.7	91.2
2014	1604	0.1	8.4	91.5
2015	1603	0.1	8.8	91.1
2016	1438	0.1	9.0	90.9
2017	1644	0.1	7.9	92.0
2018	1684	0.0	8.1	91.9
2019	1769	0.1	7.8	92.1
2020	1621	0.1	7.6	92.3

The main subject of waste collection, treatment, and disposal activities and material recovery are small enterprises. In addition, the total number of subjects of this type of economic activity for 2010–2020 is decreasing, which is a sign of a decrease in the attractiveness of working conditions.

Evaluation of the dynamics of production volumes in functioning waste management circuits (including construction) made it possible to identify different growth rates of performance of their activities. Production volumes related to waste collection (code 38.1) for 2012–2020 increased by 3 times, waste treatment and disposal (code 38.2) – 4.4 times, material recovery (code 38.3) – 0.8–1.3 times (Fig. 2). The determined

dynamics of production volumes show that the highest growth rate of activity is associated with the placement of waste in specially designated places (landfills).

The main factors that ensured the growth of the results of activities related to the maintenance of landfills are the increase in tariffs for the placement of waste at landfills and the amount of waste. The growth of waste collection activities was ensured through the selective introduction of a waste sorting system. However, the growth of waste collection volumes had practically no effect on the activities of grinding, cleaning, and sorting waste and its processing into secondary raw materials (Fig. 2). The use of regression analysis made it possible to build a regression equation and reveal the reliability of data approximation. Thus, the trend of behavior of waste collection activities is described by linear approximation with the reliability of the trend line to the actual data $R^2=83.62\%$, which indicates a high level of proximity of the trend line to actual data. Forecasting the behavior of waste collection activities based on the constructed linear approximation indicated a trend of further growth in revenue from sales of products.

Material recovery activities have the highest approximation accuracy $R^2=74.25$ for the fourth-power polynomial trend, which indicates an unstable dynamics of the initial analysis data. Forecasting the behavior of changes in material recovery activities demonstrates a possible decrease in revenue due to an increase in the amount of waste placed at landfills and the lack of market mechanisms to stimulate demand for secondary materials from waste.

The constructed trend lines and regression equations confirm the need to adopt a set of incentive measures for the restoration of materials and the growth of secondary resources of the economy.

Analysis of the profitability of activities related to the collection, processing, and disposal of waste and the restoration of materials showed that the main reason for the decline in the number of enterprises is a decrease in the level of profitability of their activities (Fig. 3).

Thus, the existing potential of small enterprises can ensure the implementation of operations of not high labor intensity and capital intensity (collection, sorting) but is not capable of operations that require significant financial costs (for example, crushing construction waste).

The main reasons for the lack of dynamics of positive changes in waste management in Ukraine are the lack of balance of economic interests of the state and business in this field of activity. The economic interests of the state are declared in the National Waste Management Strategy in Ukraine until 2030 and they are the increase in the level of waste recycling. The economic interest of enterprises is profitability. According to statistics, the economic imbalance of interests has led to the fact that more than 83 % of the total volume of construction waste generated is located at landfills and places of their temporary storage [27].

In such a situation, the waste generated as a result of hostilities will not be recycled without changing the conditions for the formation of the economic interest of the participants in the construction waste management chain.

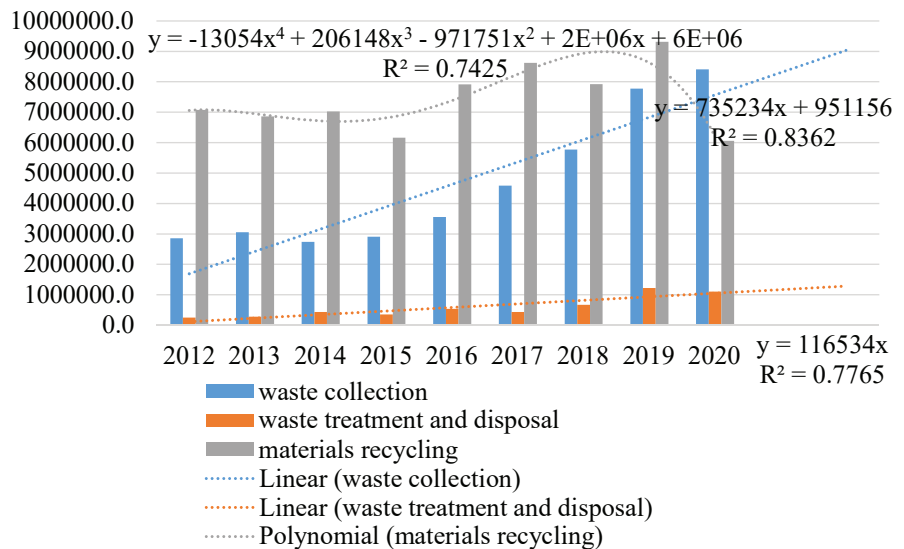


Fig. 2. Dynamics of production volumes (works, services) of activities related to the collection, treatment, and disposal of waste, material recovery, thousand UAH [25]. USD/UAH: 2012 – 7,99; 2013 – 7,99; 2014 – 11,88; 2015 – 21,84; 2016 – 25,55; 2017 – 26,59; 2018 – 27,20; 2019 – 25,84; 2020 – 26,96

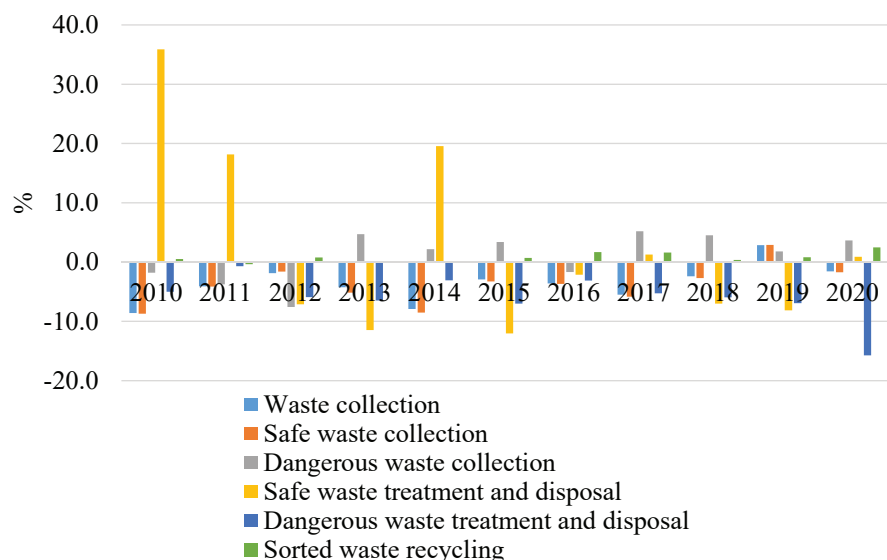


Fig. 3. Profitability of operating activities related to the collection, treatment, and disposal of waste, recovery of materials [26]

5. 3. Ways to stimulate the formation of long chains of construction waste management

Waste management is a set of measures for the collection, transportation, treatment of waste, and subsequent care of waste disposal facilities [28]. The waste management chain is a set of sequential operations and relationships between their participants that arise in the process of performing technological actions from waste disposal sites to waste disposal. Each chain is characterized by length (the number of technological operations) and width (the number of participants who implement a certain technological operation).

As for the existing length of the construction waste management chain in Ukraine, it mainly consists of a set of transportation operations from the places of their formation to the landfill for storing large-sized and construction waste. The obligation to export construction waste, its preparation for reuse, recycling, other material recovery, including backfilling, is defined in the Law "On Waste Management". However, the mechanisms for activating and controlling such operations remain uncertain, the absence of which will lead to an increase in the area of waste landfills formed as a result of the war. According to the Ministry for Communities and Territories Development, there are already 6 thousand landfills in Ukraine with a total area of almost 9 thousand hectares [29].

There are two chains of construction waste management in the world:

1) short, providing for their placement at landfills of construction waste;

2) long – the use of construction waste as secondary resources in construction (when laying roads, producing low-grade cement grades).

The removal of waste generated during hostilities to landfills is:

1) dangerous because of the possibility of ammunition that poses a threat to human life and health;

2) prolonged environmental threat as a result of decomposition and toxic effects of asbestos, plastic, lead, linoleum, soft roof, etc. on human health;

3) economic losses of secondary resources that can be used in the processes of restoring the destroyed economy of the country;

4) loss of employment potential and reduction of social benefits;

5) loss of revenues to the state budget;

6) waste removal increases the expenditures of state and local budgets.

The increased costs of forming short chains of management of construction waste generated as a result of hostilities consist of transportation costs and the cost of placement in existing landfills or temporary storage sites.

The formation of long management chains by recycling construction waste into secondary materials reduces environmental risks, increases employment, changes the structure of its participants.

As for the practice of obtaining secondary materials from construction waste, it should be emphasized that today there are opportunities to choose the technology for the production of secondary concrete from construction waste. Patent activity also testifies to the technological feasibility and economic feasibility of producing secondary concrete. Only in 2021, 2 patents for inventions of the technology for the production of secondary concrete from construction waste were

filed in the register of the World Intellectual Property Organization [30] (No. 202110310582,3; No. 202110618405,1).

The presence of a national infrastructure for the production of building materials, technologies for the production of secondary concrete, the practice of using waste in road construction confirms the possibility of organizing the production of secondary materials from construction waste. However, in a situation of unpredictable accumulation of waste, there is a need for urgent adoption of state incentives for the formation of long-term management of them.

The length of the waste management chain determines the number of its participants and takes into consideration the costs of each of them, which together will form the price of the supply of secondary materials for its processor. The use of construction waste as a backfill in the construction of roads imposes funding for all expenses on state and local budgets.

When using secondary construction materials for cement production, the high costs of implementing the waste management chain reduce the economic efficiency of the production of such cement from construction waste. The significant cost and lack of constant demand for crushing products does not create economic incentives for their acquisition by business entities. Consequently, the demand for results is the only incentive for the activities of all participants in the waste management chain. In order to create a demand for secondary construction resources, it would be advisable to adopt amendments to building codes with the obligation to use a certain share of secondary construction resources during the construction process.

Only market demand for secondary resources will make it possible to obtain additional resources in the economy, increase the number of business entities, the level of employment, get closer to the implementation of the National Waste Management Strategy until 2030 and reduce landfill areas.

The formation of market demand for secondary construction resources occurs mostly due to market tools. In a situation of lack of market demand, but if it is necessary to realize national interests, it is possible to use administrative tools to influence the formation of market demand. Such tools are the legally enshrined obligation to use secondary resources obtained in the process of processing construction waste, state regulation of the price of secondary cement. The incentive for the formation of market demand is also special programs of state financing for the introduction of innovative technologies in the field of construction waste management. The need to introduce administrative tools to influence market demand is also due to the need to reduce the cost of obtaining secondary resources from construction waste, without which their competitiveness will remain low.

The war with Russia led not only to the destruction of this country's infrastructure, the death of some active part of the population, and a decrease in resources of economic, labor, intellectual potential, but also an increase in unemployment. The decline in the number of enterprises and the increase in unemployment led to an increase in the volume of public social spending for persons who lost their jobs and were in the war zone.

Such an unplanned increase in budget expenditures and a decrease in the level of employment require the creation of new jobs. The formation of conditions for the organization of processing of construction waste generated as a result of hostilities will increase employment, attracting additional personnel to the implementation of technological opera-

tions. Increasing the level of employment not only reduces the financial burden on the budget but also creates flows of additional revenues to the state, local budgets, and pension funds. In accordance with existing system, deductions from wages in Ukraine are: UST – 22 % (paid by the employer), personal income tax – 18 % (withholding when paying wages), military fee – 1.5 %, Therefore, the remuneration of one employee ensures the return to the budget and extra-budgetary funds of 41 % of its size.

Thus, the processing of waste, in addition to obtaining additional resources of secondary materials, the increase in the profitability of business entities in the field of their management will increase employment and budget revenues.

Analysis of the state of waste management in Ukraine made it possible to identify the main problems that impede the effective disposal of construction waste. They are the predominant activities of small enterprises, low profitability of operating activities, lack of appropriate tools for state stimulation of waste processing, lack of administrative regulators or economic incentives for the use of secondary building materials. Thus, regardless of the ownership of destroyed infrastructure (private, municipal, state), the efficiency of construction waste management will be formed subject to the appropriate use of state incentive tools for their processing. The condition for ensuring the effectiveness of the waste management chain is the assignment of individual chains and geographical locations to the participants in their implementation. This will ensure employment, provide guarantees for the performance of a certain amount of work and establish responsibility for personalized participants. The implementation tool is government contracts. Thus, small enterprises can be involved in the processes of collection and sorting of construction waste, large and medium-sized enterprises can provide waste crushing operations.

Fixing the links of the chain and geographical locations for the participants in their implementation is possible via bidding. This will make it possible to identify those of the entities that have the necessary technical means and competencies for the management of relevant waste. The system of government contracts will provide long-term guarantees for participants in the construction waste recycling chain and will stimulate their internal development.

6. Discussion of results of investigating the impact of state and economic incentives on the formation of a construction waste management chain

Under the conditions of war, the management of construction waste, massively formed as a result of the destruction of the country's residential and industrial infrastructure, depends on the conditions that ensure the activities of all persons interested in this process. Conditions of activity are formed under the influence of state rules and regulations or the market environment. The ratio between state and market regulation is determined primarily by the state interest, which implies the rapid and complete disposal of the generated waste. In such a situation of priority of state interest, there is a need to change the rules and regulations that would lead to an increase in the activity of the private sector in the disposal of construction waste. To study the possibility of Ukraine to form an effective system for managing construction waste generated in the course of hostilities, the existing stimulating mechanisms that existed in the pre-war period are summa-

rized. The results of the analysis showed a lack of legislative support for the development of the processing of construction waste, which can lead to an increase in the volume of waste placed at landfills. In the context of war, the issue of construction waste management needs to be addressed immediately through amendments to the laws on building codes and the adoption of a regulatory act on the regulation of prices for secondary cement. The proposed changes to establish a standard for the use of secondary cement in construction and a fixed price for their sale to construction companies will make it possible to form long chains of construction waste management.

Economic analysis of the impact of the existing conditions for ensuring activities related to the collection, treatment, and disposal of waste and the restoration of materials revealed a low level of the culture of construction waste recycling that has developed in Ukraine.

To intensify the involvement of private entrepreneurship in all parts of the chains of management of construction waste formed during the war, a state initiative is needed in the formation of public-private partnerships. Ukrainian legislation provides for the possibility of using a wide range of tools and forms of partnership, the effectiveness of which will be achieved only if the economic interests of the state and all participants in waste processing are balanced.

The need to introduce incentives to increase the level of processing of construction waste was emphasized in [7], where the incentive for the growth of construction waste processing was the motivation of the processor. One of the ways of such motivation is the growth of government subsidies to increase the production of secondary building materials [2]. In contrast to these works, the current work proposes a set of tools to influence not the support of participants in the waste management chain but the formation of demand for secondary building materials, which activates their activities. This becomes possible due to the proposed amendments to the legislative acts that regulate the norms of use of secondary cement and regulate the minimum purchase price of such cement by construction companies. The management of a significant amount of waste generated as a result of hostilities is possible through the implementation of public-private forms of partnership, bidding procedures for the selection of partners, the consolidation of territories and the distribution of obligations among the participants. The proposed recycling of construction waste will reduce its volume, create new jobs, reduce unemployment, as well as budget expenditures.

The limitations of the study are the impossibility of calculating the economic effect due to the lack of choice of a specific technological solution for the production of secondary cement.

The obtained results reflect the state of the area of construction waste management as a prerequisite for making state decisions on the introduction of incentive tools for attracting private entrepreneurs in the field of construction waste management. A change in the legislative framework that will change the attractiveness of activities in this area will lead to a change in its condition.

The disadvantage of this study is the lack of correlation between the incentive and the result of construction waste management, due to the lack of a system of incentives in the Ukrainian economy aimed at increasing the level of waste recycling.

The development of this study is possible in the direction of analyzing potential environmental threats that arise with various methods of managing construction waste.

7. Conclusions

1. In the context of the need to eliminate the consequences of war, the state has a function of disposing of waste generated in the war zone. In the pre-war period, all the activities of the participants in the construction waste management chain were regulated by the norms common to all areas of activity. The exceptions were value added tax benefits. The result of that situation was the accumulation of 83.3 % of construction waste in specially designated places and the recycling of only 16.7 % of construction waste.

2. Economic analysis of the impact of the existing system of state regulation on the performance of waste management revealed that the main subject of its activities are small entrepreneurs (92 %). Of the total number of small enterprises, 60 % are micro enterprises. Such a structure of participants in waste management chains limits their ability to perform the entire complex of operations and requires fixing the areas of activity in the management of waste generated as a result of hostilities.

Functional analysis showed that in the construction waste management chain, the highest rates of profitability growth were demonstrated by activities related to waste disposal in specially designated places (landfills) (440 % for 2012–2020). Low profitability (0.2 % in 2020) became a

de-stimulating factor and led to a decrease in the number of participants in the waste management chain.

3. The accumulation of significant amounts of waste generated as a result of hostilities requires the need for stimulating support for participants in the management chain with such waste. The direction of such support is the influence of the state on the formation of market demand for secondary materials produced from construction waste. Administrative methods of forming such demand are as follows: legally enshrined requirements for the mandatory use of a certain share of secondary building materials in new construction, state regulation of the price of secondary cement. The tools for securing responsibility for participants in the long chain of construction waste management are government contracts and state financing for the introduction of innovative technologies for the production of secondary materials.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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