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SUSTAINABLE DEVELOPMENT OF CONSTRUCTION CONTRACTORS OF THE REPUBLIC OF MOLDOVA IN THE CONTEXT OF WASTE GENERATION AND PROCESSING

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Abstract. The article deals with the formation and processing of construction waste resulting from the activities of construction organizations. Every year there is a growth in the volume of construction products, which leads, among other things, to an increase in the volume of generated waste. The aim of this scientific research is to study the preconditions of sustainable development of construction enterprises in the Republic of Moldova in the context of waste management. As a hypothesis, it was assumed that the scale of formation and processing of construction waste affects the profitability of contractors. The initial information for the research was the data characterizing the activity of the construction enterprises of the Republic of Moldova for the last 6 years. Methods of economic analysis and methods of correlation regression were used as research methods. The results of the correlation analysis showed that 99.27% of the profitability of sales of construction enterprises depends on the factors reflecting different aspects of waste formation and management, which makes it possible to directly create prerequisites for long-term and efficient management of construction waste.

Keywords: *construction enterprises, construction waste, profitability of construction enterprises, correlation analysis.*

Rezumat. Articolul se referă la formarea și prelucrarea deșeurilor rezultate din activitățile organizațiilor de construcții. În fiecare an se înregistrează o creștere a volumului de produse de construcții, ceea ce duce, printre altele, la o creștere a volumului de deșeuri generate. Scopul acestei cercetări științifice este de a studia premisele dezvoltării durabile a întreprinderilor de construcții din Republica Moldova în contextul gestionării deșeurilor. În calitate de ipoteză, s-a presupus că amploarea formării și prelucrării deșeurilor rezultate din construcții influențează profitabilitatea antreprenorilor. Informația inițială pentru cercetare au constituit-o datele ce caracterizează activitatea întreprinderilor de construcții din Republica Moldova pe parcursul ultimilor 6 ani. Ca metode de cercetare au fost utilizate metodele de analiză economică și metodele de regresie a corelațiilor. Rezultatele analizei de corelație au arătat că 99,27% din rentabilitatea vânzărilor întreprinderilor de construcții depinde de factorii care reflectă diferite aspecte ale formării și gestionării deșeurilor, ceea ce

face posibilă crearea directă a premiselor pentru gestionarea eficientă şi pe termen lung a deşeurilor din construcţii.

Cuvinte-cheie: *întreprinderi de construcții, deșeuri din construcții, profitabilitatea întreprinderilor de construcții, analiza de corelație.*

1. Introduction

Sustainable development of construction enterprises on the basis of resource conservation is an important topic that goes beyond the activities of enterprises in this sector of the national economy [1]. Comprehensive solution to the use of secondary construction resources affects the fields of economics, sociology, ecology, etc. Taking into account the fact that the material resources of the planet are limited and some of the resources are irreplaceable, it seems interesting to study the current situation with the formation and recycling of waste from construction enterprises in the Republic of Moldova and to assess the relationship between waste and the efficiency of these enterprises.

It is known that construction activity is characterized by increased material intensity of construction and installation works [2]. Material costs constitute 50-65% in the cost of construction products [3]. Therefore, the reduction of material costs in the total cost of construction and erection works serves as one of the key directions of increasing the efficiency of production and ensuring long-term development of contractors [4].

Specialists believe that when using secondary construction raw materials, the cost of production is several times lower compared to the cost of production obtained from primary natural resources [5]. Consequently, the management of construction companies should be interested in the specialization of construction and installation works, allowing in the presence of skilled workers and developed technical base to ensure the implementation of construction and installation work on condition of minimizing waste generation, as well as the use of recycled secondary raw materials in the production.

Minimization of waste generation is possible through the implementation of effective management of construction waste recycling system, from the design of new facilities, to their dismantling and further use of secondary construction resources [3].

If the issues of recycling and disposal of construction waste arise immediately at the time of waste occurrence - it is reflected in the quality of secondary construction raw materials, which can be regarded as incomplete material for construction [6, 7].

In addition to gaining economic benefits as a result of effective waste management, construction companies contribute to the environmental situation in the country, since most waste is harmful to the environment.

Based on the above, the purpose of this scientific research is to study the prerequisites for sustainable development of construction enterprises in the Republic of Moldova in the context of formation and processing of waste, which are formed during construction activities and the presence of which cannot be completely excluded, even with the presence of modern technologies.

As a hypothesis, we can assume that the scale of formation and processing of construction waste affects the growth of profitability of contractors.

2. Research Methodology

The initial information for the study was the official data of the National Bureau of Statistics of the Republic of Moldova regarding the activities of construction companies for the last 6 years (the period 2016-2021).

General methods of economic analysis were applied as methods of research. In particular, methods of statistical data processing and correlation regression. Correlation analysis allowed us to comprehensively study and measure the influence of various factors on the economic phenomenon, when the relationship between the result indicator and the arguments is uncertain.

The advantage of this method is the ability to consider the desired factors and their impact on the performance indicator by including variables in the mathematical model, for which there is no functional relationship with the economic phenomenon.

3. Results of the study

3.1. Characteristics of the construction industry in the Republic of Moldova and the dynamics of generated waste

According to the National Bureau of Statistics of Moldova, 1,886 contractors were engaged in construction activities in 2021 [8]. The total value of construction works and services in 2021 was 24226.8 million lei (Table 1).

Table 1

Dynamics of the main performance indicators of construction enterprises

Indicators	2016	2017	2018	2019	2020	2021
Cost of construction products (works and services), million lei	15623.2	17020.4	20087.7	20981.2	24650.9	24226.8
Net profit, million lei	1169.5	1794.8	2229.6	2136.9	2028.7	2384.5
Return on sales, %	21.1	20.9	22.7	20.5	19.8	21.0
Cost of long-term assets, million lei	9 365	9 724	10 760	11 290	11 915	13 310
Annual growth of long-term assets, million lei	412	359	1035	530	625	1395

Source: Compiled by the authors based on [9-11].

For the period from 2016-2021, the activity of construction contractors in the Republic of Moldova is characterized by a steady growth in the main performance indicators. In particular, the value of construction products increased in 2021 compared to 2016 by 55.1%, net profit - more than 2 times. Despite the relatively volatile nature of the annual growth rate of long-term assets, their absolute value increased steadily and increased by 42.1% in the period under review. The dynamics of return on sales, as the most key indicator of construction companies' activity, underwent insignificant changes and in 2021 its level was 21.0 %.

Based on the fact that the main amount of waste, respectively potential secondary construction resources is formed during reconstruction and overhaul (up to 70.0%) and in the manufacture of dismantling works (up to 15.0%) [1], it seems interesting to consider the structure of construction works and its dynamics (Table 2).

Structure of construction works, %

Indicators	2016	2017	2018	2019	2020	2021
Total	100.0	100.0	100.0	100.0	100.0	100.0
New construction	58.3	50.5	44.9	50.7	49.3	56.4
Major repairs	20.4	24.4	28.3	25.5	25.1	21.9
Maintenance work and current repairs	17.9	23.2	25.1	22.2	23.9	19.2
Other works	3.4	2.0	1.7	1.7	1.7	2.5

Source: Compiled by the authors on the basis of [8, 10].

Based on the data presented in Table 2, we can conclude that in the structure of works performed by construction organizations in the Republic of Moldova, the share of major repairs and maintenance and current repairs is quite high and ranged from 38.0% in 2016 to 53.4% in 2018 during the period under review. In 2021, the share of these works decreased to 41.1% due to an increase in the share of new construction.

The dynamics of formation and recycling of waste from construction companies is shown in Fig.1.

Based on the data presented in Figure 1, we can conclude that the dynamics of construction waste is extremely unstable, which makes it difficult to predict the volume and organize effective waste management and recycling. However, a positive fact is that the amount of recycled waste tends to grow. In 2021, the amount of recycled waste was 421 tons, which was 2.5 times more than in 2020.

Figure 1. Dynamics of Generation and Processing of Waste of Construction Enterprises.
Source: Compiled by the authors on the basis of [12].

Table 3 shows the dynamics of the share of generated construction and demolition waste in the total amount of waste generated.

Dynamics of the share of generated construction and dismantling waste in the total amount of generated waste

Indicators	2016	2017	2018	2019	2020	2021
Share of generated construction and dismantling waste in the total amount of generated waste (total), %	0.25	1.04	2.72	0.16	1.50	3.17
Share of recycled construction and demolition waste in the total amount of recycled waste (total), %	0	0.02	0.01	0.04	0.05	0.17

Source: Compiled by the authors on the basis of [12].

Based on the data presented, we can state that the share of generated construction and dismantling waste in the total amount of generated waste is small (3.17%), but has a stable growth trend. The share of recycled construction and dismantling waste in the total amount of recycled waste is also assigned (only 0.17%).

The most informative data to assess the situation with waste management can be the calculation and analysis of the dynamics of complex indicators, calculated on the basis of absolute indicators. One of such indicators can be the amount of recycled construction waste in relation to the value of construction products (table 4).

Dynamics of the amount of recycled construction waste in relation to the value of construction products

Indicators	2016	2017	2018	2019	2020	2021
The quantity of recycled construction and demolition waste, tons	0,00	100	100	100	168,6	421,0
Cost of construction products (works and services), million lei	15623.2	17020.4	20087.7	20981.2	24650.9	24226.8
The amount of recycled construction and demolition waste per 1 million lei of the value of construction products, tons per 1 million lei	0.000	0.006	0.005	0.005	0.007	0.017

Source: Compiled by the authors on the basis of [9, 12].

The data presented in Table 4 shows the positive dynamics of growth in the amount of recycled construction waste in relation to the value of construction products during the study period.

Another interesting indicator may be the comparison of payments for allowable emissions of pollutants stipulated by legislation with the increase in the value of long-term assets (including fixed assets), as a guarantee of the implementation of technical progress at the enterprise, contributing to minimizing waste generation and improving the quality characteristics of secondary construction raw materials (Table 5).

Table 5

Dynamics of payments accrued to construction companies for permissible pollutant emissions

Indicators	2016	2017	2018	2019	2020	2021
Accrued payments to construction companies for permissible emissions of pollutants, thousands of lei	207.0	254.5	149.6	141.5	254.0	421.6
Accrued payments to economic entities for allowable emissions of pollutants TOTAL, thousands of lei	8995.7	10894.1	9148.4	6058.6	9716.1	7737.5
Share of payments accrued to construction companies for permissible pollutant emissions in total payments, %	2.3	2.3	1.6	2.3	2.6	5.4
Increase in long-term assets attributable to 1 leu of accrued payments for allowable emissions of pollutants, leu/leu	1990	1411	6918	3746	2461	3309

Source: Compiled by the authors on the basis of [11, 12].

In 2021, construction companies paid 421.6 thousand lei for permissible emissions of pollutants, which amounted to 5.4% of the total value of payments realized by economic agents of various activities of the national economy.

3.2 Multifactor mathematical stochastic model for establishing the relationship between waste generation and management and performance of enterprises in the construction industry of the Republic of Moldova

To improve the situation in the field of waste management, the management of construction enterprises should ensure a systematic increase in the value of long-term assets

in relation to accrued payments for allowable emissions of pollutants. Thus, in particular, in 2021 for 1 leu of accrued payments, the construction companies increased the value of long-term assets by 3,309 lei.

It seems interesting to offer the management of construction companies an effective tool to establish a link between the indicators characterizing various aspects of waste generation and management and performance of these enterprises.

The following input data were used to construct a multifactor mathematical stochastic model (Table 6).

Further, the results of the correlation analysis are presented, with the help of which it is possible to establish the degree of connection between the profitability of sales of construction enterprises and the above considered indicators characterizing different aspects of waste use and costs for environmental payments. In the course of the analysis, it was possible to reveal the linear-correlation connection between the profitability of sales and the following indicators considered as influencing factors:

x_1 - increase in long-term assets attributable to 1 leu of accrued payments for allowable emissions of pollutants, leu/leu;

x_2 - the amount of recycled construction and demolition waste per 1 lei of the value of construction products, tons/1 billion lei;

t - time, years. The number of observations was 6 (2017-2021).

The multiple correlation equation is as follows:

$$Y = 20.7499 + 0.0004 * x_1 + 0.1406 * x_2 - 0.6146 * t. \qquad (1)$$

Table 6

Input data for correlation analysis

Years	Return on sales, %	Increase in long-term assets attributable to 1 leu of accrued payments for allowable emissions of pollutants, leu/leu	The amount of recycled construction and demolition waste per 1 lei of the value of construction products, tons/1 billion lei	Time, years
	(Y)	**(x_1)**	**(x_2)**	**(t)**
2016	21.1	1990	0.000	1
2017	20.9	1411	5.875	2
2018	22.7	6918	4.978	3
2019	20.5	3746	4.766	4
2020	19.8	2461	6.840	5
2021	21.0	3309	17.377	6

Source: compiled by the authors.

The test of regression coefficients by Student's test showed that their value is significant, since the calculated reliability of the correlation coefficient is higher than the tabulated value (Table 7) [13, 14].

Table 7

Regression coefficients according to Student's test

Parameter	Coefficient	Critical value of Student's T-test	Calculated Student's T-test
Intercept	20.7499	0.1469	141.2687
b 1	0.0004	0.000	14.6358
b 2	0.1406	0.0182	7.7122
t	-0.6146	0.0570	-10.7781

Source: compiled by the authors.

The economic sense of the obtained regression coefficients means:
- b_1 - an increase in the annual growth of long-term assets of construction companies in relation to the value of accrued payments for allowable emissions of pollutants by 1 thousand lei will lead to an increase in the profitability of sales of construction companies by 0.40 percentage points;
- b_2 - an increase in the volume of recycled construction and demolition waste in relation to the production value of construction companies by 1 ton/million lei will increase the profitability of sales of construction companies by 0.14 percentage points;
- t - each year the profitability of sales of construction companies decreases by an average of 0.61 percentage points (for this set of factors).

The obtained value of the coefficient of determination (0.9927) indicates the integrity of the relationship equation. The change in the profitability of sales of construction companies by 99.27 % is influenced by the factors included in the mathematical model. The correlation coefficient is 0.9964. The estimation of the results by Fisher's criterion showed that the value of the multiple correlation coefficient is considered significant because F calculated = 91.185 more than F tabulated = 19.3 [15] (number of degrees of freedom f1=6, f2 = 6-3-1=2 and significance level q=0.05).

4. Conclusions

Ensuring effective waste management is a priority for enterprises of the national economy, including construction. With the positive dynamics of the main performance indicators of contractors (volume of construction products, net profit, long-term assets), a certain challenge remains the inability to predict the volume and organization of effective waste management and recycling.

Improving the efficiency of construction enterprises is the main condition for their sustainable development, including by improving the situation in the field of construction waste management.

According to the results of the correlation analysis, the profitability of sales of the considered enterprises depends on 99.27% of the factors included in the mathematical model, reflecting various aspects of waste formation and management, which makes it

possible to directly create prerequisites for long-term functioning through the management of construction wastes.

To make improvements in this area, it is necessary when designing new buildings to think in advance about the construction materials that will be used in its construction. This measure will allow waste to be managed at all stages of the life cycle of construction projects.

Measures in the field of waste processing should ensure the use of modern technologies that maximize the safety of secondary building resources, while reducing the cost of enterprises to protect the environment.

In the future, special attention should be paid to the detailed classification of waste in order to identify new areas of waste recycling.

Conflicts of Interest: The authors declare no conflict of interest.

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