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Sustainable Design and Building Information Modeling of Construction Project Management towards a Circular Economy

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Abstract: Sustainable design and building information modeling have introduced challenges and opportunities to improve the efficiency of construction project management. The use of circular economy principles provides an opportunity to improve not only environmental indicators but also economic ones. This study addresses sustainable design and BIM in construction project management through circular economy principles. It aims to analyze the impact of using building information modeling on sustainability indicators measured through costs. For research purposes, the basic parameters of sustainability in the construction industry were defined as recycling rate and reductions in waste and CO_2. The research questionnaire sample consisted of 199 respondents from Slovakia, Slovenia, and Croatia. Data were processed and evaluated through descriptive statistics, and then tests were used for data distribution. Statistical significance was determined through ANOVA and Kruskal–Wallis tests. Pearson's correlation analysis was used for data processing. The trends in the research results suggest that sustainable design can be achieved using building information modeling. They also pointed to an impact on sustainability through increasing the recycling rate and reducing the amount of waste. Although these results indicated a trend, this was not confirmed by the statistical significance tests.

Keywords: sustainable design; building information modeling (BIM); construction project management (CPM); circular economy

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1. Introduction

The construction industry defines sustainability as meeting requirements regarding environmental protection, social well-being, and economic prosperity [1]. Further research indicates that sustainability and sustainable design in construction mainly focus on environmental and social aspects. However, it is also crucial to consider economic sustainability in the context of construction projects and companies [2]. Many studies show that sustainability in construction is related to environmental and economic aspects but less to social aspects [3]. When assessing the sustainability of the entire life cycle of a construction project, it is essential to consider criteria that include the categories of environmental, social, and economic sustainability. Each category includes several sustainability indicators associated with different phases of the project life cycle [4]. Considering the efforts towards transforming the construction industry in view of sustainability, it is desirable to understand the relationship between the economic sustainability and performance parameters of construction projects [5].

The term economic sustainability in the construction industry is defined as a cyclical process that considers input as well as output factors. At the same time, it represents an assessment of the long-term impact on economic activity [6,7]. The basic principles of economic sustainability in the construction industry are the ratio of maximum output to minimum input and the integration of the short-term returns and long-term benefits of construction projects (The University of Manchester Research, 2003). Based on the definition of the three pillars of sustainability in construction, of which economic sustainability is one [8], sustainable building design includes designing public spaces in the context of green infrastructure. This includes water and air purification, climate regulation, nutrient and soil cycling, natural waste decomposition, habitat provision, and services and benefits for the community, both health and socio-economic, such as conditions for sport, housing quality, and healthy lifestyles [9].

The perception of costs in the context of economic sustainability is complex and must be viewed primarily from the perspective of life cycle cost management. In another study, economic analysis and its indicators allowed for a comprehensive assessment and decision-making process for a proposed construction project's effectiveness in road transport [10]. The accurate calculation and evaluation of all cost components is important for making correct decisions on economic efficiency.

Within sustainable design, the user's perspective and user-oriented design are important. In the digital age, there is an emphasis on contextual design in the construction industry, which brings a new dimension to data and building information modeling. Therefore, the mentioned studies indicate pressure for increased use of CD and data modeling, primarily regarding buildings' psychoacoustic, architectural, environmental, and economic aspects [11–13].

Incorporating circular economy principles into construction project management presents opportunities to optimize the use of resources, minimize waste generation, and improve overall sustainability [14]. Available statistics indicate a high share of construction waste production, up to 10 billion tons worldwide [15]. This is unsustainable in the long term. The reason for this level of waste may be the current approaches in several economies. Currently, the linear economy represents an unsustainable model from the point of view of environmental impacts. This is because of the one-way flow from raw materials to waste [16]. For the sustainable design of buildings that consider circular economy principles, several challenges can represent barriers to achieving the goals. These obstacles include the need for standardized methods and the need for evaluation tools [14]. This issue is also discussed in studies from Saudi Arabia. Overall, however, this is a global problem in the construction industry [17,18].

The issues of sustainable design and building information modeling, together with economic sustainability, were discussed in several studies (Table 1). In many cases, they focused on monitoring key performance indicators in the construction industry and in projects. It should be noted that these results have always led to findings obtained through monitoring significant indicators. However, they have not provided results on the impact of using building information modeling for the purposes of sustainable design in construction project management.

Table 1. Studies on key performance indicators and BIM technology for sustainable design.

	Nasrollahzadeh a Basi [19]	**Hana et al. [20]**	**Ofori-Kuragu et al. [21]**	**Davis et al. [22]**	**Khanzadi et al. [23]**	**Sara Fanaei et al. [24]**	**Bilal et al. [25]**	**P.N.Cacho, Utrilla et al. [26]**	**Das a Ngacho [27]**	**Mbugua et al. [28]**
Cost	✓	✓	✓	✓	✓	✓		✓	✓	✓
Defect Cost										
Profit	✓			✓			✓			

Table 1. *Cont.*

	Nasrollahzadeh a Basi [19]	Hana et al. [20]	Ofori-Kuragu et al. [21]	Davis et al. [22]	Khanzadi et al. [23]	Sara Fanaei et al. [24]	Bilal et al. [25]	P.N.Cacho, Utrilla et al. [26]	Das a Ngacho [27]	Mbugua et al. [28]
Productivity	✓	✓	✓	✓			✓			✓
Scheduling					✓					
Quality	✓		✓	✓	✓	✓		✓	✓	✓
Building Defects					✓					
Client Satisfaction	✓	✓		✓		✓			✓	✓
Project Delivery	✓	✓	✓	✓	✓	✓		✓	✓	✓
Sustainability (waste and CO_2)	✓		✓	✓	✓		✓	✓	✓	✓
Recycling—rate of increase						✓		✓		
Safety	✓		✓	✓					✓	✓

Globally, the construction industry is the main contributor to resource depletion and environmental impacts, consuming 50% of all extracted raw materials [29]. The circular economy is gaining increasing attention as a means of promoting sustainable development [30–33]. The European Buildings Directive (EPBD) aims to increase buildings' renovation rate and circularity, requiring full life cycle emissions reports for new buildings. As stated in a comprehensive study, building information modeling is one of the possible digital tools for improving sustainability and the environment [34]. The study provided a comprehensive overview of digital tools and a detailed literature search of sources and research, which also focused on the connection between building information modeling and sustainable design in construction regarding circular economy principles.

The optimization of resources was also addressed in studies from Slovenia with the aim of optimizing costs and contributing to sustainability in the construction industry [35]. Likewise, other studies support the importance of the topic and the monitoring of performance parameters for sustainable design and building information modeling in construction [36,37].

In the context of digitization, other studies support that information technologies contribute to sustainable solutions and thus increase the overall sustainability of industries [38–40].

2. Materials and Methods

2.1. Research Problem, Aim, and Hypothesis

The current digital age and the possibilities of information technology bring opportunities to streamline the construction project management process to achieve a high degree of sustainability. Sustainability can be approached from several perspectives. In the context of the circular economy, it is primarily an effort to reuse waste and materials—to recycle—but also to share and reduce costs, i.e., the economic aspect. Economic sustainability also plays a role in the pursuit of sustainability on a comprehensive scale. On the other hand, efforts to reduce the cost of materials can lead to an increase in recycling rates. A very similar situation can arise with the need to reduce the volume of waste and thus reduce the costs of this process. Reducing emissions can also lead to cost reductions, whether saving fuel, energy, or other raw materials; reducing CO_2; or reducing the carbon footprint. Linking and tracking costs in terms of increased recycling rates and reduced waste and CO_2 production can be achieved through building information modeling.

The implementation of specific information technologies can have an impact on key indicators of sustainability. To automate processes and increase the degree of digitalization, there is room to implement BIM (building information modeling) in designing and managing construction projects in every phase of their life cycle.

Based on a thorough analysis of already available studies and research on the construction industry and BIM, no comprehensive studies of the impact of the use of BIM technologies on the sustainability cost parameters of construction projects in the context of the circular economy have yet been carried out.

The main aim of this research is to analyze the impact of the use of BIM technologies in the management of construction projects in Slovakia, Croatia, and Slovenia on selected sustainability indicators in the context of economic sustainability, i.e., cost parameters.

Based on thorough analyses, the following indicators for monitoring and questioning the impact of BIM on costs were defined:

- Recycling rate (cost savings associated with a higher recycling rate);
- Reduction in waste production (cost savings associated with a smaller volume of waste);
- Reduction in CO_2 emissions (cost savings associated with a reduced carbon footprint, i.e., reductions in transport costs, emissions themselves, and ancillary costs associated with activities aimed at ensuring environmental protection and waste management).

Based on the research questions, the research gap, and the analyses, the following null hypothesis was established for the group of indicators in terms of sustainability and the impact on cost during construction project management:

H_0. *The use of BIM technology does not impact the sustainability indicators measured through cost.*

In contrast, an alternative hypothesis was established:

H_1. *The use of BIM technology impacts the sustainability indicators measured through cost.*

2.2. Research Design

This research aimed to analyze the impact of BIM technologies on sustainability indicators measured through costs in construction projects by implementing the following research steps. In the first step, a thorough analysis of sources and relevant studies was carried out, especially those from the last ten years. Considering the topicality and dynamics of the study, the period of the last ten years was decisive from the point of view of the development and increase in popularity of the research topic and problem. This step used primary and secondary data, which were drawn from relevant databases such as the Web of Science and Scopus.

This study considered the views of and interviews with representatives of the scientific community, primarily from partner faculties in the countries of Croatia and Slovenia, where the research was also implemented, but also both Slovak faculties and foreign representatives from foreign universities and faculties focused on the construction industry. Primarily, qualitative primary data were necessary to clarify the given issue and raise basic research questions, and the research problem was also significant.

Later, the results of the systematic analysis and subsequent application of induction and deduction established research questions related to the impact of BIM on the sustainability indicators measured through the cost savings associated with recycling rate (higher recycling rates) and reductions in waste production (smaller volumes of waste) and CO_2 emissions (reduced carbon footprint, i.e., reductions in transport costs, emissions themselves, and ancillary costs associated with activities aimed at ensuring environmental protection and waste management).

Once the primary research questions and the research problem were determined, the research goal and sub-goals, the fulfillment of which supports the main goal, were subsequently defined. Solving the research problem required data collection and processing. The next step was to ensure the collection of the required quantitative research data, i.e., the determination of the method of data acquisition, the processing of the tool (questionnaire and structured interview) for data collection, and the data collection itself.

The collected data were prepared and sorted for statistical processing, for which tools of the statistical apparatus were used. Subsequently, statistical testing and data analysis took place. Basic and advanced statistical programs such as MS Excel for Mac (ver. 16.77) and IBM SPSS software (ver. 29.0.2.0) were also used during the data processing.

2.3. Data Collection and Processing

The basis of data collection included the determination and clarification of the research focus, the structure of the studied areas given the research objective, and the use of research methods. For this purpose, a questionnaire survey was used, i.e., obtaining research data through a structured questionnaire and a structured interview based on the questionnaire, in which the obtained data were entered to ensure their measurability, compatibility, and comparability. The selection of the respondents and the preparation of the contact database were based on data from statistical offices and a database of contacts from the commercial sector provided by suppliers, developers, and other entities operating in the construction industry. Based on data from the statistical offices of individual countries, as well as Eurostat, a random selection of respondents was made, which provided an accurate degree of representation of individual subjects and projects in the construction markets where the research was conducted, i.e., Slovakia, Croatia, and Slovenia. The research was carried out in 2023.

The monitored markets are relatively small. If we look at the number of entities performing construction activities, there are around 140,000. However, a large number, approximately 40,000, are self-employed or one-person small businesses. It is much more relevant to track the number of projects. Considering the research focus, the respondents represent 199 projects. Considering the size of the market, the research sample is adequate in terms of the number of projects, as it covers 1.23% of the current construction projects at the given time.

Among those included were participants in construction projects, namely investors, designers, main contractors, and sub-contractors.

The questionnaire's structure represented three primary research areas to meet the research goal and sub-goals for individual areas and to search for established assumed correlations and relationships between individual variables. The research questions were divided into the following areas based on the form of data and the research sub-objectives:

- Characteristics of the research sample;
- Evaluation of the rate of use of BIM technologies in construction projects;
- Impact on selected sustainability indicators measured through economic parameters such as costs.

In the first step, the data processing was based on methods primarily intended to verify the correctness of the data and the research questions asked through the questionnaire. For these purposes, Cronbach's alpha was used in the research to verify the appropriateness and relevance of all research questions [41].

A Likert scale was used, where options were distributed on a scale from 1 (low rate of use or very weak influence on the selected indicator) to 5 (high rate of use or very strong influence on the selected indicator). To appropriately select tests for statistical processing and fulfill the conditions for the distribution of research data, an investigation of the normality of the distribution was carried out for each research area, or, in other words, an analysis of whether the research data were normally distributed. These findings can be obtained using graphical tools such as histograms, Gaussian curves, and QQ charts, based on an examination of the data through descriptive statistics, especially mode and median values and the coefficients of skewness and kurtosis, or by performing statistical tests to obtain the normality of the distribution, such as the Shapiro–Wilk, Kolmogorov–Smirnov, or Jarque–Bera tests.

The dependence between the variables was investigated through correlation and regression analyses. This research is based on the Pearson correlation, also known as the Pearson Product Moment Correlation (PPMC). It suggests a linear relationship between the two datasets. Simply put, it determines whether there is a dependent relationship between two variables. Due to the nature of the data, Spearman's correlation analysis was also used in the processing. It was necessary to verify whether the results of the correlation analyses were statistically significant. This was carried out through regression analysis at a level of significance of $\alpha = 0.05$.

It has the following form [42,43]:

$$r_S = 1 - \frac{6\sum_{i=1}^{n}(R_i - Q_i)^2}{n(n^2 - 1)} \tag{1}$$

However, although Spearman's correlation coefficient indicated relationships, according to Winter et al., the Pearson correlation coefficient is more appropriate. Therefore, these data were analyzed based on this indicator [44].

When testing groups of data with a normal distribution, the ANOVA and Student's T tests were used. Otherwise, non-parametric tests were used, such as the Kruskal–Wallis and Mann–Whitney U tests.

This research was carried out in small countries of roughly the same economic level. On the one hand, for comparison purposes, it meets the condition of similarity between the monitored markets in terms of volume and size. On the other hand, it does not capture the trends of large markets of large countries. That said, these countries are full members of the European Union and together form a specific representative sample of the Union. The same applies to the region where they are located.

2.4. Research Sample

This research focused on the construction industry through specific construction projects in Croatia, Slovakia, and Slovenia. The distribution of the construction projects according to the countries in which they were implemented can be seen in Figure 1.

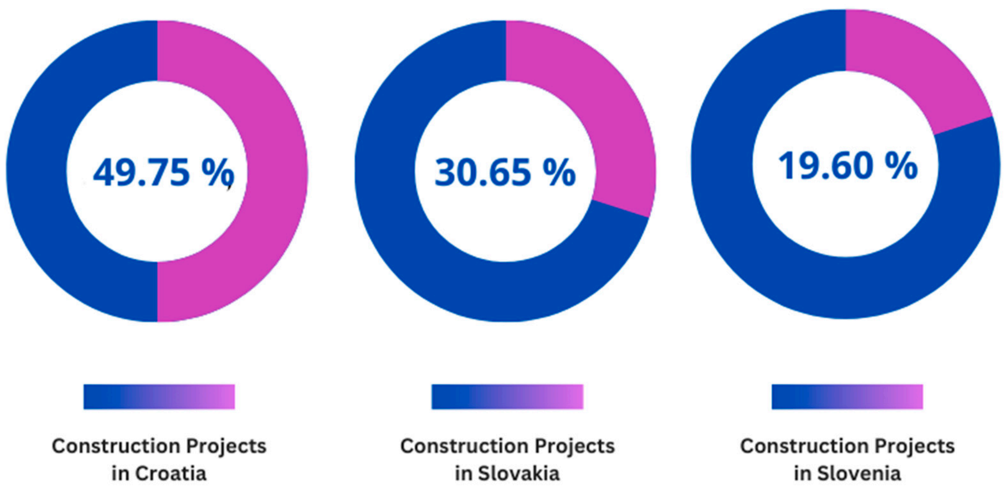

Figure 1. The structure of the research sample according to construction projects and countries of implementation.

Construction projects implemented in Croatia represented the most significant proportion: up to 49.75% of the research sample. In total, 30.65% of the construction projects were in Slovakia, and the fewest respondents were from construction projects in Slovenia. The representation of the research sample is uneven, but it considers the critical parameter of the quantification of current projects in the implementation phase.

Another investigated factor in using BIM technologies and assessing their impact on sustainability indicators through costs is the size of the projects. For the quantification of the size of the construction projects, the law on public procurement was used as an authoritative measure, which defines and quantifies terms such as large and above-limit orders and projects, medium-sized and below-limit orders and projects, small projects, and the volume of investments. The structure of the research sample according to the size of construction projects is described in Figure 2.

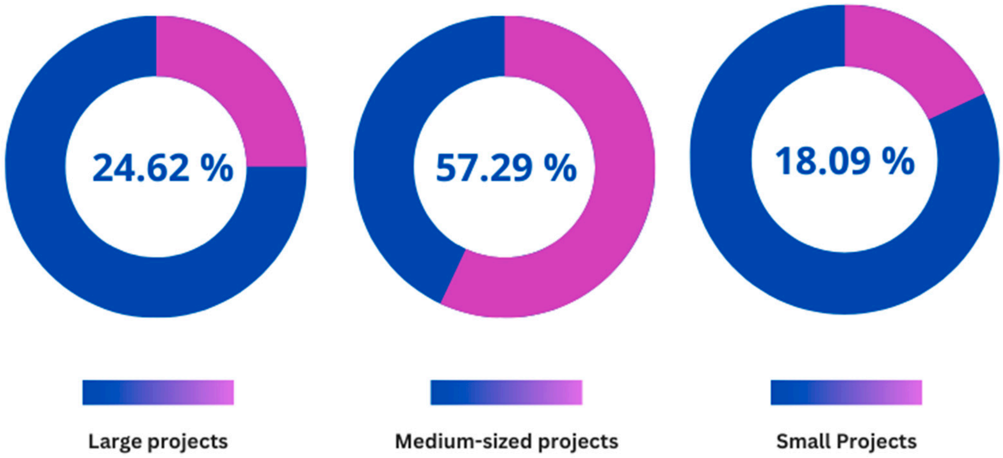

Figure 2. Structure of the research sample according to the size of construction projects.

Overall, 24.62% of the respondents in the research sample stated that they are currently participating in large construction projects; the information used to process the results for the given research issue relates to these projects. As many as 57.29% were participating in medium-sized projects, and 18.09% of the research sample consisted of small construction projects.

A total of 199 respondents representing construction projects contributed to Cerlk's research. Specifically, there were 49 large, 114 medium–large, and 36 small construction projects.

The structure of the research sample based on the NACE classification (The Statistical Classification of Economic Activities in the European Community), or the main construction activity, is shown in Figure 3. Almost 40% of construction projects are residential buildings. This type of construction project was present in the research samples for all countries studied. The construction of residential buildings is part of every construction market and is a relatively current topic not only in Slovakia but also in Croatia and Slovenia.

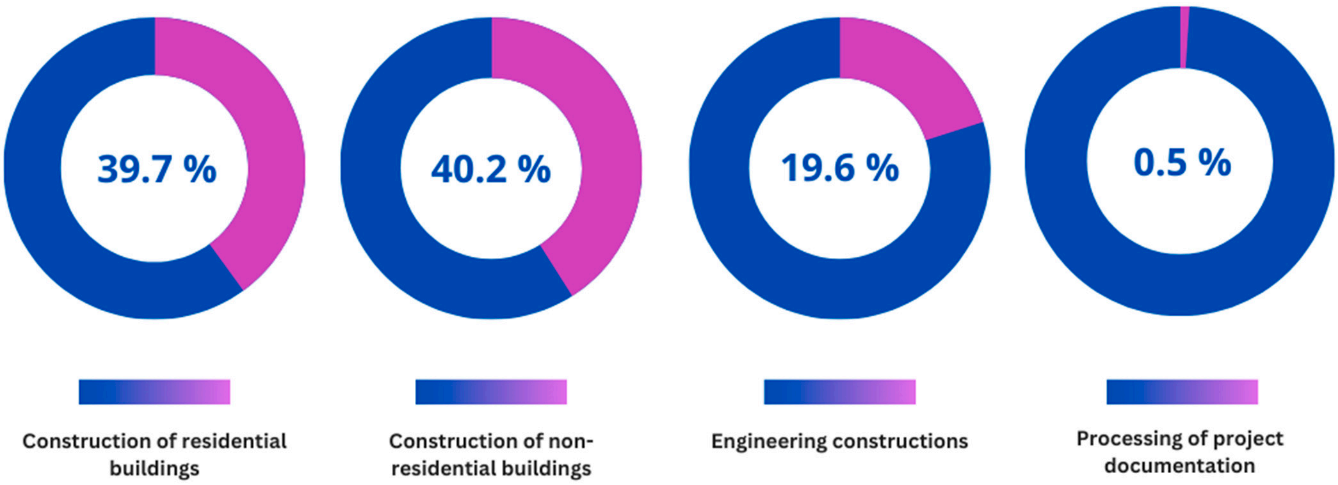

Figure 3. Structure of the research sample according to the size of the main activity (NACE classification).

2.5. Research Limitations

By monitoring sustainable design and the impact of using building information modeling in construction project management with circular economy principles, this research provides a view of sustainability through economic parameters and cost elements. The results of 5D BIM can be transferred, and the effects can be monitored. While this agrees and corresponds with the definition of sustainability, it only focuses on the economic side of it. However, if the starting point is the perception that economic sustainability is also necessary for overall sustainability, this view is correct.

Another limitation of the research may be the assessment of sustainability through cost parameters associated with select activities within the principles of the circular economy. Since sustainability is understood through components such as social, environmental, and economic sustainability, it may not be possible to draw conclusions on overall sustainability. However, since the research addresses the issue of economic sustainability and the connection with the principles of the circular economy, these concerns can be eliminated.

The research sample represents three countries and types of projects. The participants and the primary database were obtained from relevant sources such as statistical offices. Their selection was random. The addressed projects and enterprises were based on a proportional distribution according to units in the national economy. This means that the selection was proportional to the total number of projects and subjects. However, it was not possible to influence which subjects participated in the research. In order to avoid interfering with and influencing the research sample and the objectivity of the results, the research sample is anonymous but may not reflect the real representation of projects in the research.

3. Results and Discussion

This section provides a comparative analysis of the results on disparities in the use of BIM between countries. Higher rates of use of BIM for almost all the activities were recorded for projects implemented in Slovenia compared to Slovakia and Croatia (Figure 4).

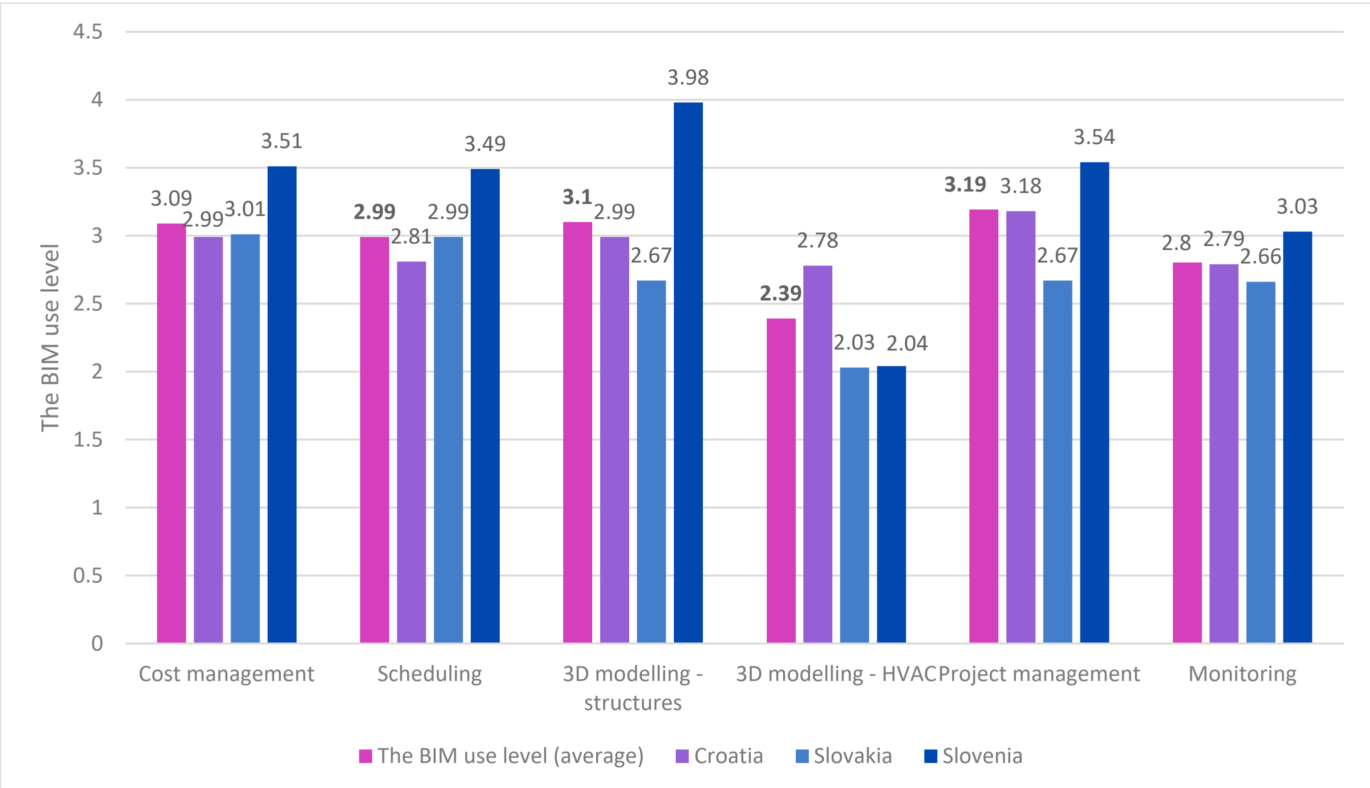

Figure 4. The BIM use level for selected activities in the monitored period (comparison of countries).

It is necessary to look for the reasons for the positive trend in the rate of use of BIM. On the one hand, project managers report the popularity of BIM and a better awareness of its potential. On the other hand, there are better opportunities in the educational process, and it is introduced during studies, providing graduates with better preparedness for the construction labor market. Business relations with foreign companies and efforts to increase labor productivity and achieve overall goals in the field of digitization in the construction industry and national economies have also contributed to the wider use of BIM technologies. Investors with requirements for the use of BIM represent a large proportion of the participants in construction projects, which has affected the rate of use in the countries under study.

The sustainability of construction projects can be assessed from several perspectives. Considering the research issue and formulated research goal, the results were analyzed in terms of economic sustainability, considering costs and the economic impact on the selected research area. In the context of the circular economy, it is assumed that increasing the recycling rate and subsequent use of materials saves costs. This impact has been the subject of research. Three areas of research focus on these impacts from an economic point of view (i.e., cost):

- Recycling rate;
- Reduction in waste production;
- Reduction in CO_2 emissions.

The recycling rate demonstrates the benefits from an environmental perspective. However, for research purposes, our goal was also to analyze the economic impacts and, thus, the rate from a cost perspective, as mentioned above. The recycling rate should result in material savings. In economic terms, reducing waste production also represents an economic cost saving through the efficient use and handling of waste, namely, a higher rate of recycling and an effort to reduce the amount of waste.

Finally, increased recycling rates offer a solution to the issue of carbon footprint through the reduction in CO_2 emissions, in line with the direction of the EU policy for the following periods, as well as the adoption of the Green Deal and the fulfillment of the Fit55 goals. Based on this, it is possible to see the value of the impact of BIM on the investigated key indicators of construction project sustainability in the context of the circular economy (Figure 5).

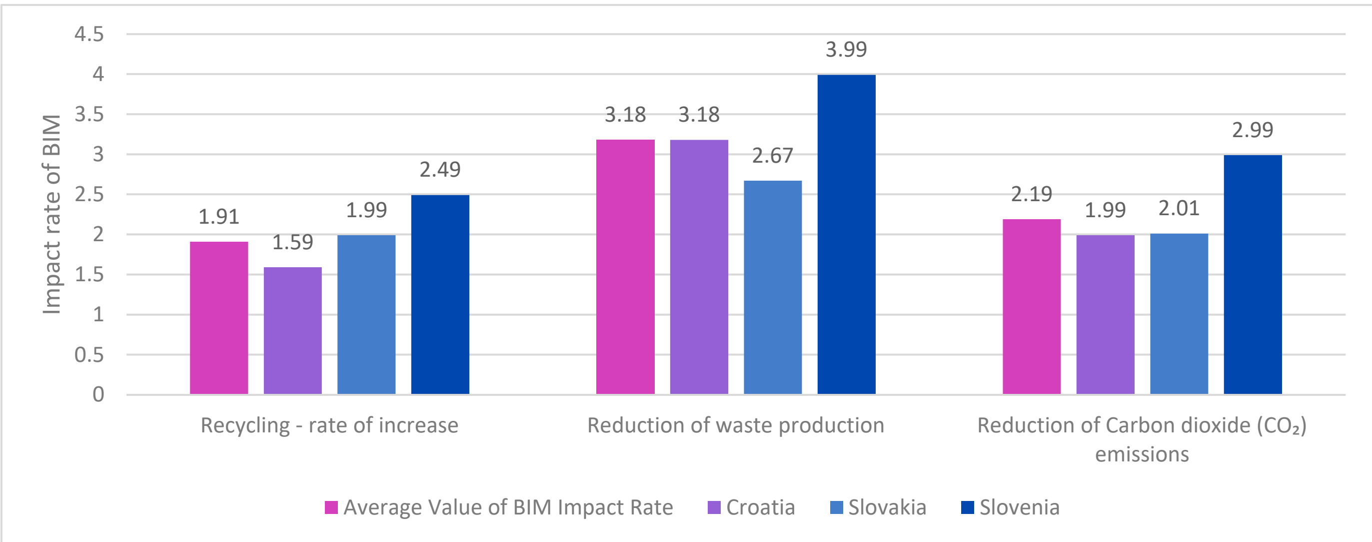

Figure 5. The impact rate of BIM on the investigated key indicators of the sustainability of construction projects in the context of the circular economy.

Sustainability in the context of economic sustainability, as already mentioned, solves ecological problems from an economic (financially measurable) point of view. The results of the data normality testing are described in Table 2. Based on the results and distribution of the data, a test of statistical dependence was chosen. Due to the size of the research sample, the Kolmogorov–Smirnov test (which is decisive for this case) was performed. Based on its results, the Kruskal–Wallis test for statistical significance was chosen.

Table 2. Normality tests for data distribution (safety indicators).

	Tests of Normality					
	Kolmogorov–Smirnov [a]			Shapiro–Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Recycling—rate of increase (impact on cost)	0.375	199	<0.001	0.607	199	<0.001
Reduction in waste production (impact on cost)	0.376	199	<0.001	0.651	199	<0.001
Reduction in CO_2 emissions (impact on cost)	0.387	199	<0.001	0.605	199	<0.001

[a]. Lilliefors significance correction.

The performed Kruskal–Wallis tests did not show statistical significance in the results for the given group of indicators. More detailed results from the statistical monitoring can be seen in Table 3. Specific values of 0.102 were recorded for overall sustainability, and some results were from 0.233 to 0.358. These pointed to a positive impact of using BIM on the sustainability of construction projects in terms of cost. However, these results were not statistically significant at the 0.05 significance level.

Table 3. Results of statistical significance testing of selected sustainability indicators.

	Statistical Significance Testing of Sustainable Indicators				Levene Test	Equality of Variances
	ANOVA		Kruskal–Wallis Test			
	F	**Sig.**	**F**	**Sig.**	**Sig.**	
Recycling—rate of increase (impact on cost)			177,215	0.358		
Reduction in waste production (impact on cost)			177,352	0.233		
Reduction in CO_2 emissions (impact on cost)			181,472	0.237		

A null hypothesis was established for the group of indicators with regard to the sustainability aspects and the impact on cost during construction project management:

H_0. *The use of BIM technology does not impact the sustainability indicators measured through cost.*

In contrast, an alternative hypothesis was established:

H_1. *The use of BIM technology impacts the sustainability indicators measured through cost.*

The research data did not comprehensively statistically confirm the results for this area of indicators, and they only partially confirmed one indicator. At the significance level of $\alpha = 0.05$, it is impossible to reject hypothesis H_0: BIM technology does not affect the sustainability of the construction project. For this reason, it is not possible to draw a conclusion or find out whether and to what extent BIM affects the sustainability of construction projects. Here, it is necessary to mention again that only economic parameters related to the environmental problems, or indicators, were monitored. From an ecological point of view, these results do not reflect the actual situation, as the research did not focus on this aspect, neither in the area of investigation nor in relation to the impacts of BIM (Table 4).

The results of statistical testing pointed to the impact of BIM on sustainability in an economic context; this claim was not statistically significantly confirmed.

These research results conclude the verification of the established research hypotheses. In the next step, the research moved on to quantify the results of the use of BIM for specific activities during the life cycle of the construction project (pre-project, project phase, implementation phase, and then the use and the end of the project). These activities and the rate of BIM use were subsequently quantified, as well as the impact on the investigated key performance indicators of construction projects through correlation and regression analyses (Table 5).

Table 4. Results of statistical significance testing of selected indicators of sustainability.

Code	BIM Impact on	*p* Value	Rejection H_0	H_1
	Sustainability of construction project (through cost indicators)	0.102	no	
A	Recycling—rate of increase	0.358	no	
B	Reuction in waste production	0.233	no	
C	Reduction in CO_2 emissions	0.237	no	

Table 5. The results of the Pearson correlation analysis for selected activities with BIM and the impact on cost items associated with sustainability.

Impact on Cost	CM	S	3D	CPM	L	M	DW
Recycling—rate of increase	0.8235	0.8480	0.7218	0.7490	0.6236	0.6799	−0.1457
Reduction in waste production	0.8873	0.7764	0.9701	0.9256	0.9689	0.7358	−0.1515
Reduction in CO_2 emissions	0.6958	0.7428	0.6067	0.6102	0.5219	0.6704	0.2553

Legend: CM—cost management; S—scheduling; 3D—3D modeling/design; CPM—construction management; L—logistics; M—monitoring; DW—demolition work.

As part of the research, specific activities performed in a BIM environment or with building information modeling tools were examined within the scope and dimensions of BIM, primarily 3D design, cost and time planning, production management, and other activities such as monitoring, demolition planning, and waste management. Above all, the relationship between cost planning and the impact on the costs of recycling, i.e., those associated with reducing waste production, was found to be strongly dependent. The findings are similar compared to those of available studies (studies on the impact of BIM on costs) [23,26,27,30,37], which confirms the need for cost planning through building information modeling and considering the impact on cost items, including the costs associated with increasing the rate of recycling and the use of materials (value 0.8224) and reducing the production of waste (value 0.8870).

There were also relationships between time planning through BIM and the costs associated with the recycling rate (value 0.8480), and 3D modeling in the BIM environment and the costs associated with waste reduction (value 0.9689). Significant dependencies were also identified between planning and construction management through BIM and reduced waste reduction, as well as planned logistics and reduced waste production.

Despite some strongly correlated relationships, the regression analysis did not confirm statistically significant results. Therefore, these dependencies cannot be considered statistically significant at the level of p 0.05. In other words, based on this methodology and the use of these statistical tools, these results point to a strong trend of the impact of the use of BIM in selected activities on the rate of costs in recycling and waste management. However, these results were not confirmed or recognized as statistically significant. The reasons for the solid correlations and the non-confirmation of statistical significance are analyzed within the discussion.

The results of the correlation analysis also yielded interesting findings. For example, there was a positive impact on the researched aspects of the rate of recycling and the reduction in emissions. However, the associated cost items have not been statistically confirmed, even though a trend, and thus a positive impact, is captured here. More significant findings regarding the intensity of the results were obtained for the 3D information modeling of buildings and the rate of waste reduction, as was also considered and mentioned in other research [25,29,35,37]. For example, the research results were also aimed at monitoring other activities implemented through building information modeling, such as 3D modeling, construction project management activities, logistics, and monitoring. In terms of cost, building information modeling had the greatest impact on the reduction in waste production, in agreement with the goals of the European Commission, which were mentioned in [32,33].

On the contrary, demolition work carried out based on building information modeling brought an increase in costs, primarily in terms of recycling and waste reduction. On the one hand, of course, there was an increase in the recycling rate, but these works produce a large amount of waste. In some cases, for these purposes, it was more efficient not to recycle the material but to accept the costs of waste management and purchasing new material. However, this point of view does not contradict sustainability principles or the circular economy.

On the contrary, larger projects saw very positive impacts of building information modeling and sustainable design, leading to a better use rate of recycled materials. However, the costs of handling these projects also developed favorably. Above all, economies of scale were the limiting factor. Likewise, the volume of waste produced was reduced, leading to further cost savings at this scale. From this point of view, every aspect of sustainability was ensured, including the economic one, which also agrees with circular economy principles. This also leads to a direct comparison of the results with the principles and goals of the Buildings Directive, where the main goal was to ensure an increase in the construction industry's renovation and circulation rate. This study agrees with another comprehensive study [29,34] claiming that building information modeling is one of the digital tools with the potential to improve sustainability and the environment.

It is also important to address the relationship between the used indicators of economic sustainability and social suitability within the sustainability framework. The results of the degree of correlation between economic activities and indicators in the optimization of costs and the rate of recycling can also be helpful. The research data show that the relationship between the economic indicators and environmental sustainability is high if there is also an economic benefit from the use of technology—the social aspect. The view is just as important. Unfortunately, the relationship between economic sustainability and social desirability is not strong enough to make the results consistent.

Economic motivation has often been considered as one of the dimensions of economic sustainability. The research sample also pointed out the importance of the social aspect as well as an awareness of the need to solve the issue precisely using the investigated indicators. However, the exact relationship was not proven here. The discussion about motivators also arose in relation to the social aspect; however, economic interest still exceeds the social dimension in many cases.

4. Conclusions

This research focused on building design maintenance and building information modeling, providing several perspectives on and impacts of economic sustainability in construction project management. Based on several studies and surveys, attention is given to the usefulness and benefits of BIM technologies in sustainable building and design and 3D modeling.

Within the principles of circular sustainability, the perception and view of the impacts of using building information modeling are more than just a view of 3D modeling. As part of the complexity of solving this issue, sustainability is also perceived through the economic dimension of the circular economy. In relation to the impact on the management of construction projects, it is primarily a cost indicator associated with sustainability.

However, the analysis of available studies and surveys points out that other key performance indicators, such as delivery and time, quality, and profit, also deserve attention. However, for sustainability, perceived through social, environmental, and economic value, it is essential to look at the indicators of environmental impacts that can be quantified economically. Specifically, the recycling rate, the need for materials, and the carbon footprint can be quantified and measured. Therefore, this research defined the monitoring of indicators such as the rate of recycling and the reduction in waste production and CO_2 emissions through cost indicators.

This research assumed that a higher use rate of BIM technologies would also bring demonstrable positive effects on the cost items under investigation. The research results pointed to the importance of using building information modeling. They also showed a positive impact on selected cost indicators for sustainability, but these results were not statistically confirmed. None of the results for the investigated impacts, such as recycling and reductions in waste production and CO_2 emissions, were confirmed at the significance level of 5%. However, these results showed a trend for each area studied. There were reductions in the costs of the rate of recycling, the use of old material, and the reductions in waste and CO_2, and thus an overall positive impact.

Specific values were recorded at 0.102 for overall sustainability. These pointed to a trend of the impact of using BIM on the sustainability of construction projects in terms of cost. However, these results were not statistically significant at the 0.05 significance level, and this is a future research direction. It is very important to look for causes and reasons when a trend is shown. This is a subject with potential for further research and investigation.

Several findings from the research can be highlighted. One of them was that building information modeling is more prominently used in large projects and companies. Likewise, in the case of comparative studies, there were differences in use in individual countries. During the correlation analysis, relationships were determined, which in many cases also confirmed a positive trend for the use of building information modeling for recycling rate and the costs associated with it. This trend was even more pronounced in the production of waste. However, even here, these results were not statistically significant. The highest degree of correlation was recorded when using the 3D tool and reducing the waste production rate to 96%. This confirms that information cloud modeling of buildings or sustainable design in construction project management is justified. The fact that these impacts and effects have not been confirmed with statistical tests for cost reduction does not mean that they do not positively affect overall sustainability. However, their impact in the context of economic sustainability and circular economy elements was not confirmed in this case.

Directions for future research are also oriented towards the use of other technologies, such as artificial intelligence vs. BIM. These are not only for the construction industry but also for society. Data volume, processing speed, and accuracy will be the subject of further investigation to assess their impacts on indicators of economic sustainability.

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