The Use of Data in BIM Technology and Effects on Profitability of Construction Projects in Slovakia, Slovenia and Croatia

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Abstract. Current technologies can work efficiently with a large amount of data. Data and information can represent competitive advantage and are also necessary decision-making tools. BIM technologies are characterized by the ability to work with a large amount of data and thereby support decision-making in the management of construction projects. From an economic and investment point of view, the question is how these progressive technologies can contribute to achieving the financial results of construction activity. In other words, this research seeks to answer how these technologies help achieve selected KPIs. The parameters of profitability were investigated as part of the research. The research was carried out based on evaluating commercial projects from three countries, Slovakia, Croatia, and Slovenia. The aim of the research is to analyze the impact of using data in the BIM environment and their impact on profitability parameters.

Keywords: BIM technology · profitability · profitability index · construction project · data

1 Introduction and Problem Statement

Data and information nowadays have a lot of value in many cases [1]. Their value depends primarily on the degree of usefulness. In other words, to what extent they can be helpful for specific purposes, for example management or decision-making [2]. Effective work with data can bring added value in the form of support for decision-making. The effort to quantify results and manage based on facts is one of the main ideas of how data can be effectively used in management in any field [3]. Current technologies can work with a large amount of data, which leads to the facilitation of some management and the adoption of economic and financial decisions [4]. Therefore, smart technologies and information and communication technologies in general represent possibilities that can have a significant impact on the results and success of decisions based on this information [5].

BIM technologies represent a tool that largely works with a large amount of data and supports parametric modeling [6]. This results in fast data processing, visualization and

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simulations that can provide important information in the planning and management of construction projects [7].

From an economic point of view, it is an opportunity to plan and later implement construction activities and thereby ensure the success of the project from an economic point of view. Here it is important to define the success of the project from this point of view. In economic terms, this represents the fulfillment of the main essence of business activities and thus the achievement of positive financial indicators. Tracking key performance indicators can provide a quick way to evaluate the success of construction projects [8].

The success of construction projects from a commercial point of view can be assessed based on profitability indicators. Therefore, monitoring basic financial parameters and their evaluation is important and, in essence, it is a necessity [8]. The use of BIM technologies should contribute to better planning and, therefore, in the implementation phase, to the use of available resources (material, work, time, but also financial parameters). This view is the basis for investigating the impact of BIM technologies and the use of data in the planning and management of construction projects. The scientific assumption is that in the case of a higher rate of use of BIM technology and provided data in this environment, it can have a positive relationship with the profitability of these construction projects. Analysis of the correlation between these variables can provide an answer as to whether BIM technologies also bring benefit in achieving selected key performance indicators, in this case profitability indicators [9].

Development projects aimed at the sale of residential or commercial premises is one of the conditions for this assessment, primarily due to the time-consuming nature of the research. Considering the investigated impacts on profitability indicators, it is a condition of this research to ensure the measurement of comparable projects and parameters. From an investment point of view, it is therefore necessary to say that these projects must be sold, not rented, for easier comparison, and for an objective assessment it is important to determine the number of units already sold. From the point of view of profitability indicators, two indicators were considered: net income, which also considers the cost parameter, as a profitability index, which considers the size of the investment [10].

2 Data in BIM Technology and Profitability Indicators

BIM technology brings challenges and opportunities, as thanks to effective data management, it is possible to plan, manage and implement construction projects effectively. Data plays a significant role in the planning and management of construction projects. Digital technologies represent a tool that, according to several studies, can significantly make these processes more efficient. What is a significant advantage for any necessary changes in the model, it is easy to make changes in the planning and prepare multiple scenarios. It is especially suitable for investment evaluation of construction projects, where several variants can be simulated and modelled in advance, also from the point of view of economic and financial parameters [11] (Fig. 1).

Building information modelling in the construction industry plays an important role not only from the point of view of 3D modelling but also in a broader sense from the point of view of cost modelling, which significantly affects the profitability of projects,

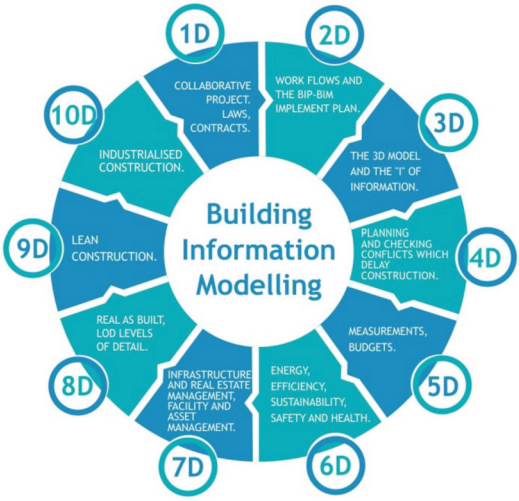

Fig. 1. Dimensions of Building Information Modelling [12].

respectively, in the evaluation of investment intentions. Within the individual dimensions of BIM, i.e., 3D modelling, time planning, and cost modelling, i.e., 5D, also plays an important role. However, from the point of view of the life cycle of construction projects and thus also the phase of use, it is necessary to pay attention to the aspect of sustainability already during planning [12].

The current situation and the instability of the prices of building materials only confirm the necessity to work with data and use the possibilities of digital technologies to change them easily and the ability to quickly incorporate new information into plans, management processes and the implementation itself. BIM technology makes it possible to change input information quickly and thus promptly model new variants, eliminating possible time and financial losses. Another benefit can be maintaining the required level of quality, minimizing unexpected situations and the like [9].

Several studies have pointed out the benefits of using information and communication technologies and tools for working with data in planning, managing, and implementing construction projects. Considering the complexity of understanding the situation, it is also necessary to mention that there are several participants with often different goals within this process. The view of the developer, respectively the investor, is focused on financial indicators and economic benefit. In this way, he also tries to quantify the construction project's success. On the other hand, the pursuit of profit, which is based on the minimization of costs, is the pursuit of every participant in the construction project. This can sometimes be in contrast with the desired level of quality [13, 14].

From a business point of view, the success of construction and development projects is assessed primarily from the point of view of investment value and profitability. This is, of course, true if the discussion is focused on commercial projects, buildings to sell housing or commercial space.

One of the studies points to the fact that this process needs to be more standardized despite some contractors' adoption of BIM technologies in the construction industry,

representing positive profitability and return results. Therefore, in this study, the procedure and standardization of the processes of not only implementation but also analysis of the costs that could have been increased if errors were not detected on commercial construction projects are proposed [15].

Another study compared BIM's impact on selecting an appropriate option in a residential construction project in China and other alternatives from an LCA perspective. As part of this, environmental and energy requirements were assessed and analyzed from the point of view of profitability. However, this study worked with only one project and other alternatives that were not implemented [16].

Also, based on this study, BIM and working with data in this environment can be helpful for key performance parameters, which are part of profitability. BIM can also be used in the assessment of the so-called PPP projects. This was also pointed out by a study where, based on BIM modelling, PPP projects were assessed based on future performance indicators, primarily financial and assessment of the so-called value for money [17].

When implementing BIM technology, it is necessary to consider the benefits, difficulties and potential risks associated with this process and use. The study from Poland contained an analysis that also included the profitability of introducing BIM in Poland, specifically on the object of a military building. The result should be a standardized procedure and a recommendation that should recommend BIM technology even when assessing the profitability of construction projects [18].

Key performance indicators represent measurable indicators that reflect the results of creative activity and can be quantified. These indicators can be viewed from several perspectives. Since it is a management tool based on which it is possible to perform essential management functions, such as planning, monitoring and control of goals, the selection and monitoring of these parameters depend on the focus of goals and defining the success of construction projects. Several sources pointed to the segmentation of key performance indicators into several groups.

On the one hand, some indicators are focused on sustainability, primarily from an environmental point of view. It is an area where, within the life cycle of a construction project, there is an effort to achieve a minimum carbon footprint and to extend the life of the construction project. Within the framework of LCA, economic sustainability can also be perceived in this evaluation process [19]. Another view of the perception of key performance indicators talks about quality indicators as a measurable result of the performance and success of construction projects. Quality indicators, which also include the rate of failures, repairs, and complaints, but also partly the lifetime of the construction product, represent not only a qualitative indicator but also a quantitative indicator that quantifies and measurably.

From the point of view of the perception of the success of construction development projects, there is the perception of economic indicators. The group of economic key performance indicators belongs to the fundamental indicators from the point of view of setting and fulfilling the financial goals of construction projects. These indicators primarily include cost indicators. Planning and cost management makes much sense in connection with the use of BIM technologies. Several studies have pointed to the correct idea of the dependence on the use of BIM technology and cost optimization. Profitability

indicators represent another group of indicators. Focusing on sales in planning, managing and evaluating the success of projects is not possible for all types of construction projects. Above all, construction projects where it is not a commercial interest but a public interest in the form of building infrastructure, non-profit projects for a public purpose, etc. they, represent a group where the use of this indicator is problematic. On the contrary, in development projects where there is an interest in constructing a building to rent or sell to end users, indicators of sales, revenues and overall profitability are very effective tools for planning and management.

Profit and sales represent the primary goal from a financial and business point of view. However, the volume of sales can depend on several factors, as well as the profit. When comparing these indicators are mainly used when comparing and analyzing construction projects of the same volume with the same purpose. Since the investigation of the impact of BIM technology and the use of data for planning and management of construction projects involves analyzing projects that differ in volume, scope and purpose, a better indicator may appear to be the profitability index or overall index indicators that also consider volume expenditure parameters. From this point of view, these indicators are more suitable for assessing the impact of data and BIM technology on the planning, management, and implementation of construction projects with a commercial purpose.

3 Methodology

3.1 Research Aim and Research Problem

This research is focused on analyzing the use of data and BIM technology in the planning, management, and implementation of construction projects to analyze the impact on selected performance indicators. Because these are development projects aimed at the sale of residences, and commercial and administrative premises, profitability indicators rebuild the possibilities of comparison and analysis of results for managers in this area. The research steps and methodological procedure can be seen in Fig. 2.

Fig. 2. Research flowchart and steps.

The aim of the research is to analyze the use of data and BIM technology and the impact on profitability indicators. The research is based on the basic idea and assumption that the use of data and BIM technology can positively improve the planning, management, and implementation of development projects. The result should be better performance indicators, the so-called key performance indicators. Performance indicators are among those based on the already mentioned reasons.

Comparing the results and analyzing profitability as a perception of the success of construction projects is an interesting perspective that should answer the consideration of BIM technologies as an aid to achieving the economic goals of the implementation of construction projects. Therefore, indicators such as profit from the sale or rental of residential and commercial buildings and premises are among those analyzed and researched. It should be mentioned that, to a large extent, this is the view of the developer, respectively, the investor. Another investigated indicator and relationship is the profitability index and the use rate of BIM technology in construction projects.

3.2 Data Collection and Data Processing

Data collection was carried out through an online questionnaire. Developers and investors of several construction projects from three countries (Slovakia, Slovenia and Croatia) were approached. The research was focused on commercial construction projects, the purpose of which was the sale of residential buildings and commercial and administrative premises. Respondents were approached to answer questions regarding using data in the BIM environment and BIM technology, primarily in the planning, management, and implementation of construction projects. The project manager, together with the finance department, answered these questions. Also, the goal was to obtain available economic performance indicators in the form of data such as project costs, profit, and profitability index.

To quantify the rate of data use in the BIM environment, a response scale from 1 to 5 was set. Based on the maximum use rate, 5 was set as the highest possible. On the contrary, 1 represents the lowest rate of use of Data and BIM technology in the planning, management, and implementation of construction projects.

Fundamental economic indicators were provided for completed projects and already in the advanced sales phase (that is, at least 80% sold or leased). It is also important to note that when renting, at least five years of project operation is considered to evaluate the projects and their economic results.

Key performance indicators, such as costs were obtained from project managers. However, from an economic point of view, it is important to examine these impacts also based on the time value factor; therefore, for an objective comparison and evaluation of the data, fundamental macroeconomic indicators are drawn from Eurostat, also because it is a comparison of projects from three countries where there is a different rate of inflation and some conditions.

Profit and profitability index were examined, among other indicators. To a large extent, these indicators are basic economic indicators.

$$PI = \frac{\sum_{n=1}^{N} \frac{NCF_n}{(1+r)^n}}{\sum_{n=1}^{N} \frac{I_n}{(1+r)^n}} \equiv \frac{NPV}{I_0} \tag{1}$$

where [20]:

CFn – net discounted cash flow in the n period,

In – initial investment in the n period (or total investment),

r – discount rate,

NPV net discounted (present) income.

These indicators were entered as variables. The dependence between these indicators and the utilization rate was investigated. This was done through Pearson's correlation analysis. The level of significance was set at $p = 0.1$.

3.3 Research Sample

The research sample represents enterprises that participated in the planning, management, and implementation of construction projects for administrative and commercial premises and residential buildings. From the point of view of examining and analyzing the profitability of indicators, this represents commercial projects where the primary goal of the developers is the profit generated by the sale and rental of buildings and premises - construction projects.

Most of the respondents represented micro-enterprises. However, many of the respondents also represented medium and small businesses, and 13% of the respondents were large businesses. Therefore, from this point of view, it is the composition of the research sample that represents the situation on the construction market in the mentioned countries.

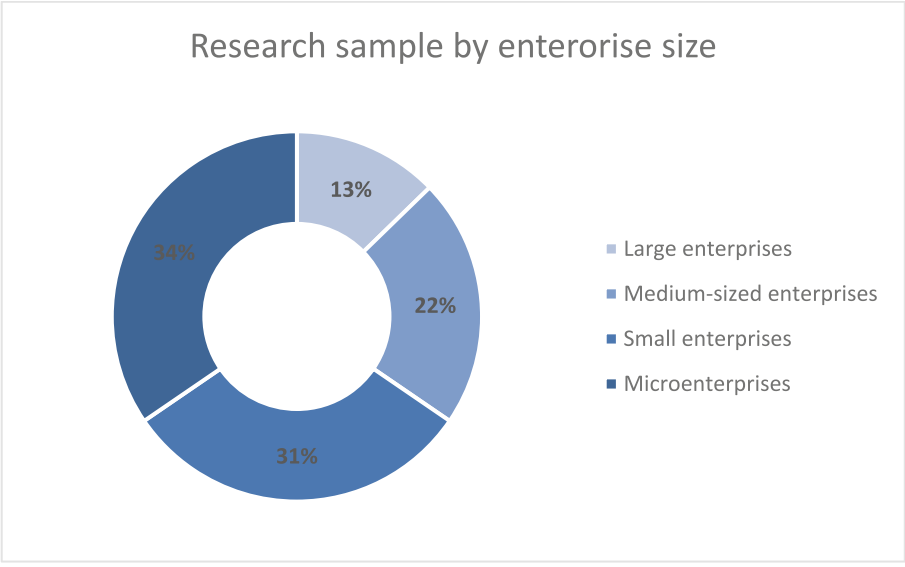

Fig. 3. Research sample by enterprise size (construction projects)

It is interesting to look at the research sample of respondents according to the implementation of construction projects in individual countries. The research was implemented on projects in Slovakia, Slovenia, and Croatia. Individual representation can be seen in Fig. 3, which reflects the representation of respondents by country. Projects implemented in Slovakia have the most significant representation. Croatia is second in the number of projections, followed by Slovenia (Fig. 4)).

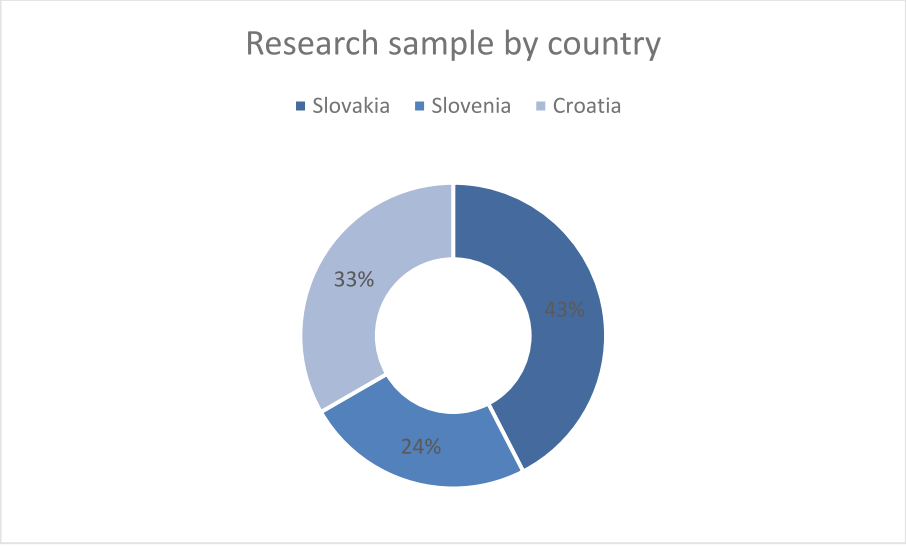

Fig. 4. Research sample by country (construction projects)

3.4 Research Limitations

The research focused on analyzing the use of data and BIM technology in the planning, management and implementation of construction projects and their results from the point of view of key performance indicators in the form of profitability index and profit. From the point of view of economic performance indicators, these indicators represent a complex view of the results, which do not consider the number of overinvested funds or the size of the project. Also, from the point of view of the neutrality of the indicators, they represent a consistent indicator that is used in several industries. From the point of view of the time value of investment and finances, this indicator is among those that work with net present value. Even so, even in this case, there may be facts that can theoretically distort the research results.

Sample size has already been mentioned and is addressed in every research. Since the distribution and geographical location of the projects are comprehensive, these results should reflect a comprehensive sample of respondents despite the smaller number of respondents.

Another possible conflict is the focus of projects. Based on the selection and determination of the research problem, only commercial projects focused on residential buildings and commercial and administrative spaces were selected. Since, in terms of investors' interest, this represents the most common construction projects in the research countries, these results cannot be generalized to all construction projects. Above all, not for those in the field of infrastructure and so on.

4 Results and Discussion

The analysis of the relationship between the use of data in the BIM environment and selected key performance indicators in the form of profitability indicators points to the trend of the positive impact of BIM technology and the use of data in favor of effective planning, management and implementation of construction projects. Figure 5 shows the relationship between data and BIM technology use in construction project management and the average profitability index. The profitability index represented high values for the companies that reported the highest use rate. This value was 2.06, representing a high return and profit rate when considering the investment. Acceptable values were also recorded for companies that use BIM technologies at levels 3 and 4 to plan, manage and implement construction projects.

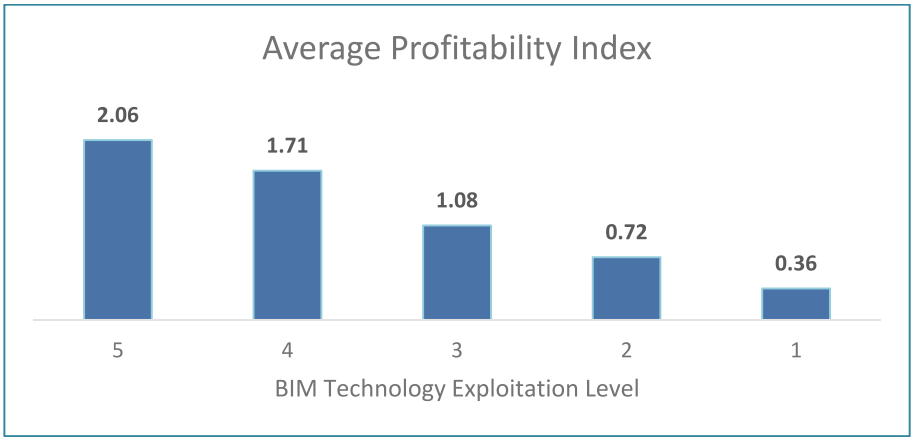

Fig. 5. Average profitability index in construction projects by utilization rate of BIM technology

On the contrary, for projects where the rate of data and BIM technology use was at level 2 and 1, i.e. of low intensity of use, the average profitability index did not even reach level 1, which represents an investment that is not suitable from the point of view of profitability in the examined period. Figure 6 describes this situation better. Cases of construction projects where the profitability index is higher are associated with a higher intensity of using BIM technology. Based on these values, a trend line was constructed to describe the dependence.

From the point of view of the limits of the research, it is possible to discuss whether it is a significant statistical phenomenon or not. As already mentioned, the research sample

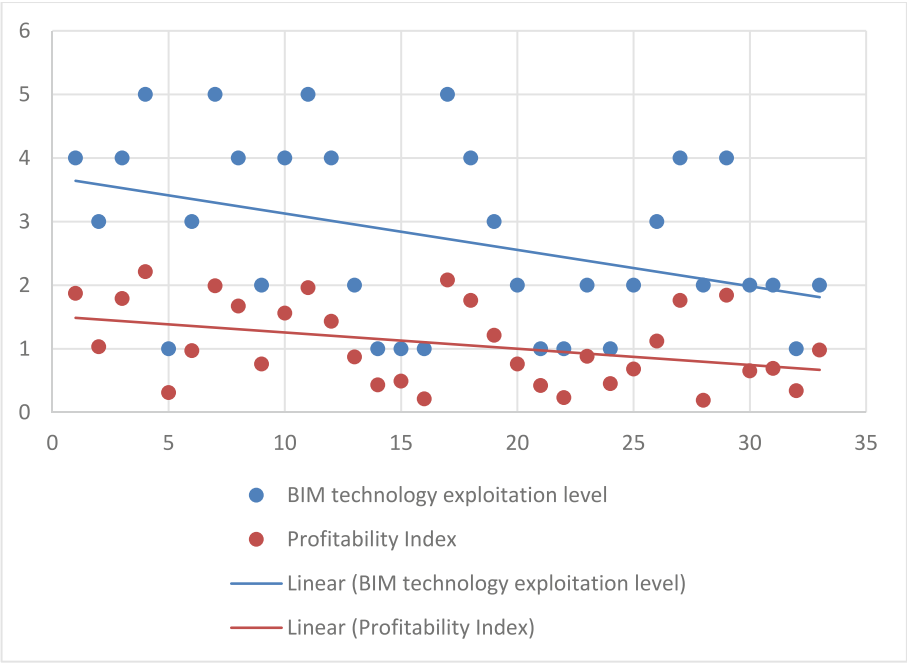

Fig. 6. BIM technology exploitation level vs. profitability index.

represents a random selection of projects that met the criteria. Based on the statistical methods used, it is possible to conclude that exact research methods were used. These results reflect the impact on the results of the projects where the level of use of BIM technology was investigated.

The next figure shows the dispersion and grouping of values in relation to the rate of data utilization in the BIM environment and the profitability of the index. This data display represents a trend that reflects not only the use of BIM technology, but also the profitability index.

Some of the already mentioned studies pointed to the benefit of using BIM technology on some performance indicators. Profit and profitability index is a specific indicator that reflects not only the performance of construction projects but also the business point of view. Since the primary goal of business a. implementation of business activities (Fig. 7).

In the context of examining the correlation and relationship between the rate of data use in the BIM environment in the planning, management, and implementation of construction projects in the context of examining the progress of profitability indicators. In the following graph, the curves show a high degree of correlation. This is also confirmed by Pearson's correlation, which shows values of $r = 0.96501$.

The following picture talks more about it. The following plots show a high degree of correlation, which only confirms the assumption that was the subject of the plot (Fig. 8).

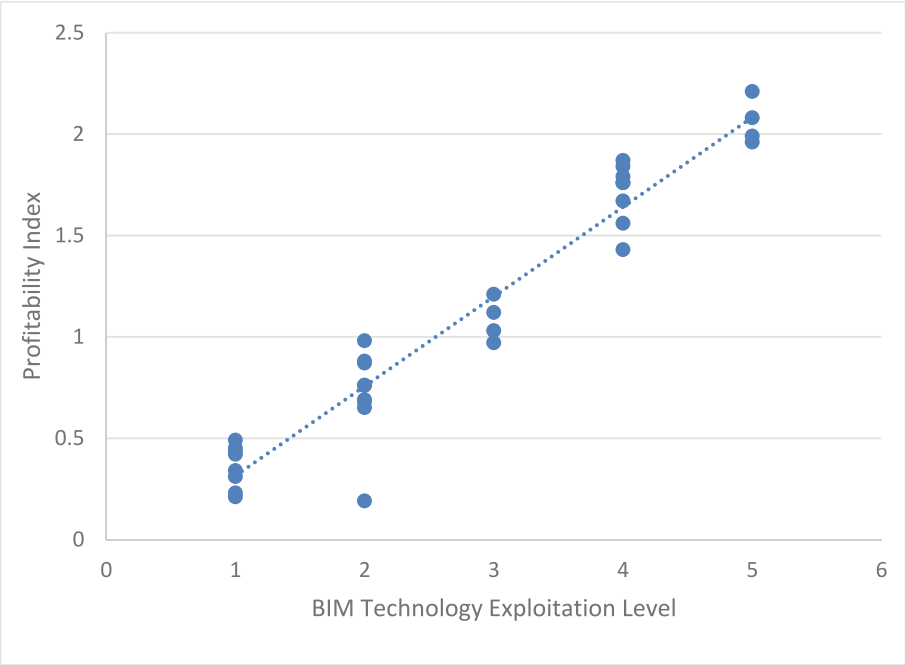

Fig. 7. Intervals between the profitability index and the use of BIM technology

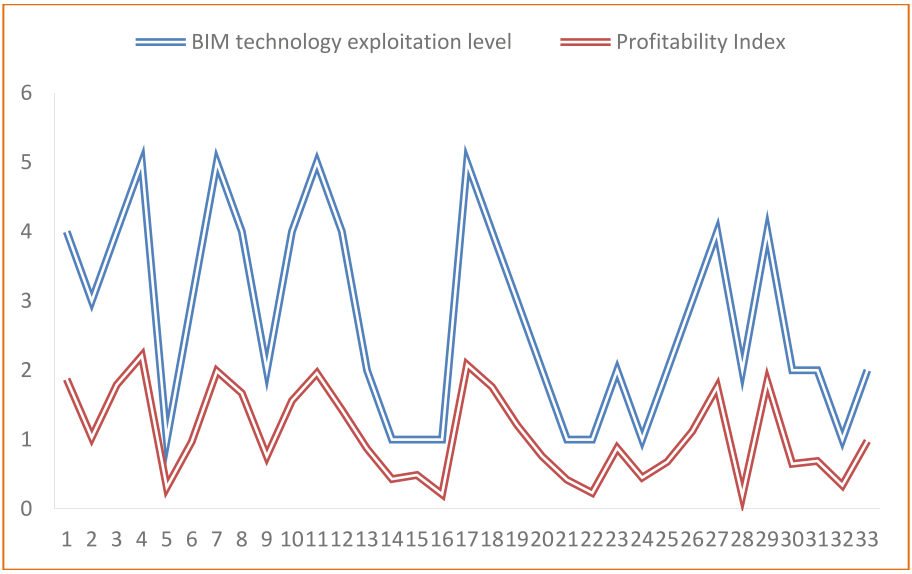

Fig. 8. Relationship and correlation between the profitability index and the use of BIM technology

5 Conclusion

Research focused on the use of BIM technology and data in relation to key performance indicators points to the modern methods of analyzing project results. The correlation pointed to a significantly positive relationship between the use of data in the BIM environment and the results of the profitability index of construction projects. In three countries. This research was carried out in three countries that have several similar characteristics. These are small countries in which the construction industry represents an important component of the creation of GDP and thus of the economy.

This relationship was investigated by Pearson correlation analysis. Despite the smaller number of respondents, who still represented the reference group of projects, an important relationship between the use of BIM technology and results in the profit and profitability index was shown. These indicators represent an important group of performance indicators that speak about the success of construction projects.

The strength of this study is the fact that the research results reflect several countries that have a similar construction industry, but on the other hand, the geographical conditions are different. The investigated projects were mainly implemented in larger cities, which also reflects the focus of the construction projects.

This research pointed to the strengths of construction projects where the investor had the goal of making a profit. This economic goal was set as a clear intention. However, achieving this goal was difficult. BIM technology as a progressive tool for achieving set goals has become a medium for their achievement.

The research, based on empirical methods, confirmed the assumption that BIM technology and data used in the planning, management, and implementation of construction projects with commercial intent has a strong positive relationship to the achievement of economic results.

In the next steps, the research should be extended to other performance indicators, which are a basic indicator of economic sustainability. Above all, cost parameters are often very important from the point of view of efficient use of resources. Likewise, in future research, there is room to expand with a new market. Above all, examine this issue in neighboring countries within the V4, or also in Western Europe and compare these results.

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