THE IMPACT OF VARIATION ORDER ON CONSTRUCTION PROJECT: PERFORMANCE, COST AND TIME

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Approval sheet of the Thesis

This is to certify that we have read this thesis entitled **"The impact of variation order on construction project: performance, cost and time"** and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

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Construction projects are a very demanding initiative and have an intense necessity for effective planning and organization as well as excellent management. One of the factors that affects the overall effectiveness of construction projects is variation orders. The purpose of this study is to reach some conclusions about the variables that affect the complexity of variation orders as well as to conclude how these orders affect overrun cost of the project. The study initiates by establishing a theoretical framework elucidating the primary factors associated with the low efficiency of projects in the construction projects. It also offers a summary on different variation orders and their effects on the overall project. Furthermore, descriptive statistics and the regression method focus on uncovering the relationships of different factors. The results revealed that the complexity of the variation orders had no impact on cost overruns, but the duration was a factor that affected the final costs. On the other hand,the results unveiled that the size of the project was a factor related to the complexity of the variation orders. The main conclusion of this study is the emphasis on the fact that the effectiveness of projects also depends on the management of changes during all phases of its implementation. The recommendations presented at the end of the study provide a simple and understandable framework for how change can be managed most effectively to ensure the success of construction projects.

Keywords: *variations, construction, Albania, impacts, causes, minimization, public.*

ABSTRAKT

NDIKIMI I URDHËRAVE TË NDRYSHIMIT NË PROJEKTET E NDËRTIMIT: PERFORMANCA, KOSTOT DHE KOHA

Pasha, Zenel

Master Shkencor, Departamenti i Inxhinierisë së Ndërtimit

Udhëheqësi: Julinda KEÇI, PhD

Projektet e ndërtimit janë një iniciative shumë impenjative dhe kanë një nevojë shumë të theksuar për një planifikim dhe organizim efektiv si dhe për një menaxhim shumë të mirë. Një ndër faktorët që ndikon në efektivitetin e përgjithshëm të projekteve të ndërtimit janë edhe urdhrat e variacionit. Qëllimi i këtij studimi është që të arrijë në disa përfundime rreth variablave që ndikojnë në kompleksitetin e urdhrave të variacionit si dhe të konkludojë se si këto urdhra ndikojnë në tejkalimin e kostove të parashikuara të projekteve. Studimi nis me një kornizë teorike të arsyeve kryesore që lidhen me efikasitetin e ulët të projekteve të ndërtimit. Në vijim, statistikat përshkruese dhe metoda e regresion fokusohet në zbulimin e marrëdhënieve të faktorëve të ndryshëm. Nga rezultatet u zbulua se kompleksiteti i urdhrave të variacionit nuk kishte ndikim tek tejkalimi i kostove por kohëzgjatja ishte një faktor që ndikonte kostot përfundimtare. Nga ana tjetër u zbulua se madhësia e projektit ishte një faktor që lidhej me kompleksitetin e urdhrave të variacionit. Përfundimi kryesori i këtij studimi është theksimi i faktit se efektiviteti projekteve varet edhe nga menaxhimi i ndryshimeve gjatë gjithë fazave të implementimit të tij. Rekomandimet e paraqitura në fund të studimit japin një kornizë të thjeshtë dhe të kuptueshme se si mund të menaxhohen ndryshimet në mënyrë sa më efektive për të siguruar suksesin e projekteve të ndërtimit.

Fjalët kyçe: *ndryshime, ndërtim, Shqipëri, ndikime, shkaqe, minimizim, publik.*

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CHAPTER I

INTRODUCTION

The one factor that is always present in the field of construction and in the projects of this sector, it is "change". Each project needs various modifications during the execution phase or even earlier in order to achieve a satisfactory level of efficiency. Due to these factors and numerous others, variation orders in this sector are a necessity. These orders are a must because they provide flexibility and make it possible for changes to be applied to different projects to result in a higher level of efficiency.

1.1 Problem Statement

When dealing with construction projects, variation orders are one of the most substantial problems you can encounter. Of course, these orders are a necessity, but even their effective management requires a lot of effort and an excellent knowledge of the sector and the project specifics. Clients or stakeholders for a project require a lot of changes and this is impossible to avoid in a sector like construction (which is also a sector that develops day by day). If a project lacks a strategy that foresees substantial changes in it, the handling of variation orders will lead to cost overruns and various problems related to customer relations. This may come as a result of the lack of rules (or the ambiguity related to them) but also as a result of the lack of communication between the interested parties. But it is also important to analyze what are some factors that affect variation orders and how their level of complexity affects other aspects of the project.

1.2 The purpose of the study

The purpose of this study is to reach some conclusions among some of the factors that are part of construction projects. The study will focus on unveiling the relationships between project deadlines (anticipated and final), level of complexity of variation orders, costs (anticipated and final) as well as project size. This study will be using both, simple and multiple regression to conclude on the variable’s relationships. It will also conclude on the model and its suitability to analyze the variables of construction projects. The data to be used are confidential. This detail also emphasizes the importance these conclusions will have for the management of variation orders in the face of the many factors that affect them.

1.3 Objectives of the study

The objectives of the study will be as follows:

- Summarizingthe general framework of conclusions on the differences between the anticipated and the final duration regarding the 30 projects that are the subject of this study.
- Summarizing the general framework of conclusions on the change of anticipated and final costs.
- To conclude on the relationship that exists between the duration of construction projects, the level of complexity associated with variation orders.
- To reach accurate conclusions through the regression model and the analysis of correlation coefficients that will benefit from the model.
- To conclude on the relationship between the complexity of variation orders and the size of the construction project.
- To comment on the suitability of the model to conduct the study on factors related to construction projects.
- Listing some recommendations on variation orders in construction projects and for overall project planning to minimize cost overruns and significant cost overruns.

1.4 Methodology

The main focus of this study is the regression model. Simple and multiple linear regression model will be used to reflect on the relationships of variation order complexity, project duration, cost overruns and project size. Through the analysis of the coefficients of the regression model we will be able to comment on the strength of the relationships of the variables and also on the suitability of the model for this specific study. The first regression analysis is the multiple linear one and focuses on project duration (independent variable), variation order complexity (independent variable) and the additional cost for each project (as dependent variable of the model).

On the other hand, the second regression model is the simple linear one that will test the relationship between two variables. In this model, a different approach is taken, considering the complexity of the variation orders as the dependent variable in relation to the project size as the independent variable. The level of complexity associated with variation orders is rated on a scale of 1 to 5, where 1 is the lowest complexity and 5 is the highest level of complexity. The level of complexity is assessed based on several factors such as technical, cost, plan, changes in strategy, etc. It is important to note that this study uses confidential data and therefore the projects are named with numerical values.

1.4 Research Questions/Hypotheses

1. How does the level of complexity of variation orders in a construction project affect cost overruns for its completion?
2. How does the length of time for a construction project affect cost overruns for its completion?
3. Is there a relationship between project size and the level of complexity of variation orders?
4. How appropriate is the regression model to infer the factors that were considered for this study?

- Hypothesis 1: There is a relationship between the level of complexity of variation orders in a construction project in exceeding the estimated costs for its completion.
- Hypothesis 2: The duration for a construction project has a significant impact on exceeding the estimated costs for its completion.
- Hypothesis 3: Project size affects the complexity of variation orders.

The regression method is among the most used methods in different studies. The reasons why this particular method was chosen for this study are as follows:

- This method can help in drawing conclusions and grasp the relationship between two or more variables. Specifically in our case, this method will help us understand the relationships between project timelines (duration), complexity of variation orders, cost overruns and size of construction projects. This model enables researchers to determine how certain variables affect other variables. In due course, this specific model can also be utilized by other researchers, starting from the fact that it provides important knowledge for construction projects.
- The model makes it possible to analyze many variables at the same time. Construction projects have many elements, so the model enables the analysis of these elements at the same time. Given this ability, regression is a valuable tool for understanding complex relationships.
- The regression model has predictive capabilities: through this method, results can be predicted depending on the values of the independent variables. This method can, for example, predict the additional costs that may be necessary for a project taking into account the duration and complexity of variation orders. Similarly, based on the size of the project, it can predict the level of complexity of the variation orders. These predictive capabilities are useful for making informed decisions and efficient planning.
- Maintains statistical rigor and confidentiality: regression analysis is widely recognized as a reliable approach for handling sensitive data. It enables researchers to draw relevant conclusions without compromising data confidentiality, ensuring that findings can be trusted and acted upon with confidence.

CHAPTER II

LITERATURE REVIEW

Variation orders are very important for construction projects, especially in cases where adjustments and modifications must be made to the project, but also to resolve disputes between the parties involved. Many studies have been conducted on this topic and many researchers have reached different conclusions. This chapter aims to reflect some of these previous studies and their conclusions.

1.1 Impact on Cost, Time, and Performance

For example, one worth mentioning is the study of (Ibbs, Wong, & Kwak, 2001). They concluded that for a project to be effective it is necessary to consider all factors such as budget, working hours, quality, and timeliness of the project. They also concluded that variation orders are important and are more likely to be needed during implementation, regardless of how much effort was put into the initial plan. The important point was how would the stakeholders manage them effectively.

A construction contract will always be subject to various modifications. Sometimes these changes are foreseen in the contract as a special clause, but there are also cases where the contracts are drawn up in such a way that always leaves room for various changes, but not in a specified manner. According to (Memon, Rahman, & Hasan, 2014), variation orders significantly affect the construction project. From the observation of different projects, they discovered that factors such as equipment, lack of professional work, non-compliance with deadlines (in alarming differences). Emphasis was put on the fact that at the beginning of the projects it is necessary to work from professionals who must design an effective strategy step by step from the beginning to the implementation of the last phase of the construction project. Consequently, this will also contribute to the effective management of variation orders.

Some of these activities that are not positive for a construction project include defects, inspections, ineffective use of available resources, etc. There are not many studies that are conducted on factors and activities that do not add any value to the projects. On the other hand, there are researchers who argued that variation orders are underestimated in construction projects. It may even happen that their influence turns out to be positive. In the field of construction, considering all factors, it is impossible to go to the end without making a change (Mohamed, 2001). Variation orders in construction projects come precisely as a result of the fact that each project is unique (Hanna, Camlic, Peterson, & Nordheim, 2002).

1.2 Consequences of Variation orders

(Bower, 2000) compiled a study on the consequences of variation orders in construction projects. Some of these were: excessive costs resulting from exceeding deadlines, inappropriate materials that directly affect practical work, inflation, ineffective management of expenses, etc. He concluded that there are many indirect costs associated with variation orders but at first glance it is difficult to understand what exactly they are a consequence of.

When the estimated completion date is significantly exceeded, the parties involved do their best to reimburse the client who commissioned the project. Variation orders are among the main causes of the significant increase in deadlines. Based on the phases in which this project faces variation orders, it will also be calculated how the cost overruns and the new deadlines will change. They also concluded that these orders also affect the overall productivity of the project (Ssegawa, Mfolwe, Makuke, & Kutua, 2002).

1.3 Impact on Cost and Quality

According to the study conducted by (Ndihokubwayo, 2008), variation orders only have a negative impact on overall project costs. He also found that most construction projects always had a backup plan included in their strategy. This backup plan consisted of an emergency fund to meet unforeseen costs. Apart from the fact that the changes have a negative impact on costs, they also reduce the quality of work. What is advised to be done at the beginning of the project is the specification of all the strategies and other necessary elements (materials, work) in order to implement the project and have as few surprises as possible (Fisk, 1997).

(Mendelssohn, Hester, Monteferrante, & Talbot, 1991) have re-emphasized the level of employee’s productivity. They are of the opinion that if employees will be forced to commit to a significant number of additional working hours, it is expected that their productivity will be reduced. Consequently, the quality of work will be negatively affected.

Meanwhile (Thomas & Napolitan, 1995) have considered the factor of variation orders, but from the perspective of work interruption and the impact this interruption has on both the productivity of workers and the quality of work. Further, they found that the cause of interruptions and variation orders was the lack of material at a certain point in time. This resulted also in difficulties in the management of work and variation orders.

1.4 Project activities that do not add value

The Swedish government carried out a study and took into consideration some of the largest subjects and the indicators related to them. They dealt with high costs, factors related to quality and possible measures that could be taken to minimize excess costs. They also concluded that there are activities other than variation orders that do not add value to the project (Saukkoriipi & Josephson).

The study, conducted by the Swedish government, focuses on high costs, factors related to quality and measures to minimize excessive costs. This study is important for understanding the impact of variation orders on construction projects. For example:

- Impact on costs: the study investigates the factors that lead to high costs, and one of the issues it relates to is variation orders. These orders lead to changes in design, materials, and scope of work. By analyzing and understanding the factors that contribute to high costs, including those related to variation orders, the government can develop strategies to manage and control costs effectively.
- Factors related to quality: variation orders will also affect quality. By analyzing step-by-step how changes affect quality, governments can understand both how variation orders affect project performance and how changes relate to the quality of work (the quality and skills with which the work is performed).
- Measures to minimize excess costs: the study proposes several measures that can minimize costs and specifically those related to variation orders. Effective communication between the parties involved in the project and an effective variation order management strategy is very key to achieving the desired results.

- Non-value-adding activities: Variation orders that result in unnecessary changes, rework, or delays. Based on these facts, they are considered activities that do not add value to the project. The identification and minimization of such activities can positively affect the efficiency of the project and the effectiveness of its total costs.

In summary, the study conducted by the Swedish government provides valuable insights into how change orders affect construction projects in terms of cost, quality and overall project management. By considering all the factors they may face during the execution of a project, governments can develop better strategies to effectively handle variation orders and optimize project outcomes.

1.5 Management of VOs

(Arain & Low, 2005) conducted a study on variation orders and concluded that unless an approach with open communication between the parties is applied, they will be very difficult to manage effectively, which will result in further problems and disputes.

(Sunday, 2010)'s study focuses on the impact of change orders on state institutions projects. The main finding revealed that change orders have a much more significant impact on projects managed by external consultants than on those handled by internal project staff. Regardless of the type or size of the project, this result was the same. The study suggests that those responsible for project management should evaluate the contributions of internal and external consultants to management effectiveness. The results of the study also provided very useful information for better stakeholder management, planning and project execution in public building initiatives by also shedding light on the distinct impacts of variation orders in these two groups. Implementing the study's suggestions can improve project efficiency, cost effectiveness, and overall project success.

(Seyar, 2020) states that variation orders in construction projects are inevitable. However, their impact can be managed through a clear plan that is precisely related to change management. A plan of this type reflects descriptions of the activities to be followed and the roles and responsibilities of the personnel involved, providing a systematic approach to handling change orders during the execution phase of the project. By objectively evaluating change orders and their impact on the initial project and focusing on controlling their impact, the parties involved in the project can minimize cost overruns and overruns, while also ensuring that the quality of work matches the purpose of the project. He also states that the evaluation of contracts is another important factor to understand the necessary approach of a variation order. From the beginning, it is necessary to take and analyze each step and make a forecast of later needs. A recommendation of this consultant and researcher is also the use of digital applications for project management and increasing efficiency in the management of variation orders.

CHAPTER III

THEORETICAL FRAMEWORK

In every scenario where a study is to be carried out, the first step is the theoretical summary on which the study will be based. By acquiring a comprehensive understanding of the theoretical framework, we may be able to enhance the structural coherence of a given study. Variation orders in construction projects are very important. Since they come as a result of various factors, it is necessary to analyze them very carefully. By listing some basic concepts related to projects, certain models, construction project management and many others, this chapter aims to theoretically examine some of the fundamental concepts related to variation orders. Those in charge of construction projects face many processes of decision-making. These decisions must be made with a comprehensive and structured level of information in order to be effective for the implementation of the project.

3.1 Definition of variation

Variation is essentially a change, a change in quantity, technique, or level. A variation in a construction sector is a supplement (addition), a substitution of something or a reduction of predetermined phases in the project contract. The term by which they are known is precisely "variation order". These changes may be the result of design modifications, working conditions, technical problems, etc. There are many cases where a stakeholder to the contract finds it easier to assign a portion of the work to a party outside the project or how are they called sub-contractors. But other parties may not agree with this decision. This will require a modification to the main contract or to the way the work will proceed.

Any modifications made to the initial project planning, any further contract specifications will be referred to as variation orders or variation orders. The essence remains the same, but the literature has many definitions in terms of variation. For example (Harbans Singh K.S. 2003) associates the word modification/change with a contract in which the project is headed by an architect who works on behalf of the other parties involved. Another author focuses on the changes that are made in the time frame of the project and in the work technique (Fisk, 1997).

3.2 Causes of Variation in Construction Projects

As we have mentioned several times, it is almost impossible to avoid the need for modifications in a construction project. In order to reduce or avoid dissatisfaction for the parties involved, a strategy should always be created that also anticipates these modifications. Many contracts in this sector are drawn up exactly in this way. They leave room for provisions that protect the project and the parties from changes that may be necessary during implementation. When it is necessary for example to apply a change to the original design, this is no small task. The variation order directly affects the contract and is the one that will reflect the change. The reasons for variation orders are varied and many. In this section we will mention only some of them, which are:

- **Difficult financial conditions** that project employers may be facing. Given these difficulties, they can make efforts to reduce the overall costs of the project. Consequently, this will also result in reductions in the quality of the project. To avoid this, it is always good precaution to design a strategy that also includes the cash flows in terms of the project (O’Brien, 1998).
- **Vague goal setting** at the beginning of the project. Because they are not well defined from the beginning, they may need to be changed during the various stages of implementation. By not having a complete framework of project elements, many surprises will emerge later (Ibbs, Wong, & Kwak, 2001).
- **Old technology or its change**: it should be thought that even in the case of changes in the conditions of the sector or updates in work techniques, the project has the possibility to adapt and reduce the costs as a whole. So, it should be thought that in a later period the objectives of the project adapt to the expected innovations in the industry (CII, 1994b).
- **Incomplete design** or not suitable for the project: neglecting a complete and adequate design from the first stage to the last stage, the need for modifications will always arise.
- **Lack of equipment**: According to (O’Brien, 1998), not having all the necessary tools to perform the work, changes will have to be applied to adapt to the resources that are already available.

- **<u>Lack of a professional in charge of the project</u>**: a good manager organizes the construction work for all phases taking care to avoid or reduce problems or delays in their completion.

3.2.1 Difficult financial conditions

Difficult financial conditions can have a very large impact on the parties involved in construction projects. They are obliged to manage these constraints effectively in order to minimize the negative effects. The following section provides an overview of the impact of financial difficulties on projects and variation orders based on the analysis of (O'Brien, 1998).

Budget constraints: due to limited resources, parties involved in construction projects find themselves faced with very limited budgets. As a consequence, these projects experience very difficult financial conditions. During the execution of the project, the need for various modifications or new requirements may arise, causing the initial budget to be insufficient. In these situations, the need for change and variation orders arises. These variation orders will affect the scope of the project and its costs, matching the circumstances of the moment. So, the limitations in the budget will also bring the need to issue these orders, in order to adapt to the demands and changes.

Cost-cutting measures: to reduce project costs, a very useful option is the use of lower-cost materials or the use of alternative construction methods (depending on the project). Such cost cutting techniques always result in poor quality work and the use of very poor-quality materials. As a consequence, all of this will lead to the need for variation orders that will make it possible to correct the decisions made. These orders are necessary as the project must maintain its target level of quality, even in challenging financial circumstances.

Delayed payments: late payments to creditors and suppliers will cause a disruption in the supply chain and project execution. Based on these circumstances, there may be a need to issue variation orders related to project timelines. Thus, payment delays will be eased and the level of effectiveness in project execution will be maintained.

Unforeseen circumstances: economic and financial crises can create very volatile situations in the market, leading to changes in prices and labor costs. These unforeseen circumstances can have a substantial impact on the overall cost and viability of the project. In these cases, managers turn to variation orders as a critical tool to react to unforeseen changes. They can apply modifications to ensure that the project continues to be carried out sustainably even in the face of financial crises.

In conclusion, difficult financial conditions can have a substantial impact on construction projects, necessitating the issuance of variation orders. Regardless of the situation that may be related to budget constraints, payment delays or unforeseen circumstances, variation orders will always be a necessity for the realization of construction projects.

3.2.2 Vague goal setting

When the objectives and goals of the construction project are not clearly defined from the outset, the need for variation orders is likely to arise during project execution. This is because ambiguity in objectives can result in unexpected situations. Since the objectives have not been well defined, during the realization of the project, new needs may arise that will require a modification in the initial plans. These modifications may relate to costs, duration, etc. Unclear goals will directly affect project costs. Despite considerable debate in practice and academic literature about variations in construction projects, there is a lack of efficient variation order management techniques. These shortcomings once again emphasize the importance of creating complete change management strategies in the project, which come as a result of unclear objectives (Ibbs, Wong, & Kwak, 2001).

Also, another issue that needs to be addressed is risk management. Setting unclear goals will also create obstacles in risk management. Potential risks may not be detected in time and, as a consequence, may not be addressed in time. As a result, when they appear during the execution of the project, they will bring about unforeseen changes that require the issuance of variation orders to reduce the negative effect on the realization of the project.

Uncertainty in the allocation of resources: when objectives are unclear, decisions on the allocation of available resources will not be made properly. Certain resources may be allocated in the wrong places or at the wrong stages. Insufficient resources may at a later time lead to delays or quality difficulties and requiring the issuance of change orders to correct resource deficiencies. Finally, how unclear objectives can affect the issuance of variation orders in construction projects emphasizes: contingencies and risk management, resource allocation (Ibbs, Wong, & Kwak, 2001).

3.2.3 Technology in use

The use of technology in construction projects affects the need for variation orders in two ways. First, advanced, and improved design technologies enable more accurate project planning. Consequently, this results in fewer variation orders during the execution phase. At the same time, the use of advanced programs that also help in conveying information in real time, makes communication between the involved parties simpler. This will also reduce the probability of the need for variation orders, as communication will be more effective, and information is exchanged in a timely manner.

By using technology appropriate to the construction sector, it is also easier to monitor all components of the project. In this way, managers and supervisors can identify potential problems more quickly. By identifying them sooner, I will intervene to fix it at the right time. This affects the number of variation orders as well as their complexity. Faster identification enables problems to be managed more quickly and to mitigate the situation from deteriorating.

Furthermore, there is the issue of prefabrication. Technology-enabled prefabrication and modular construction contribute to standardized components. In this way they minimize or eliminate changes and adjustments in place, resulting in lower costs and a reduced need for variations. But even the use of these technologies requires a very effective and careful management. If the data entered into the systems is not correct, it will result in other problems and in very ineffective management. As a result, the application of focused and well-executed technology is critical to ensure its beneficial impact in reducing the number of variation orders and improving overall project results.

3.2.4 Incomplete design

To prevent the need for variation orders and cost overruns it is important to identify the typical problematic issues associated with design in the construction industry. In complex projects where there is a lack of clarity, wrong calculations are made and there is a significant lack of data, it will result in high costs and low level of effectiveness. Accuracy is essential, but even more important is accuracy and completeness in the design of the project, which includes the practical facet (hydraulic or electrical systems) but also the aesthetic facet.

One of the reasons why the need for variation orders may arise will be the work with many designers or design teams on the same project. Mechanical, electrical, and structural errors, as well as lack of information and lack of cooperation among the teams involved in the project, affect the need for variation orders to correct the problems and implement the project as envisioned in the original plans. The parties involved in the project who have the greatest interest must be very careful that the design is complete and comprehensive. In this way, it will be possible to avoid changes and delays in the anticipated deadlines (Love, Liu, Regan, Smith, & Irani, 2017).

The main reasons for not meeting the deadlines of construction projects are design errors and inadequate designs. These are the result of insufficient site studies, delayed design work and inadequate change management procedures. According to (Dosumu & Adenuga, 2013), (Kikwasi, 2012) and British Columbia Construction Association (2011), these problems can result in the need for variation orders, conflicts between parties and also the overall performance of the project. The impact of incomplete designs and errors often leads to variation orders being issued. These orders are a response to unforeseen circumstances and are applied to manage them. Variation orders, although necessary, can complicate the progress of the project by making it more complex and can also result in higher costs in construction projects.

3.3 Variation Orders and their effects

The following table provides a comprehensive overview of several types of variation orders that are often used in construction projects and their potential impacts. Construction projects sometimes contain variation orders, also referred to as variation orders, which make changes to the original project scope, specifications, or design. These modifications may be necessary in response to customer requests, unforeseen events, design changes, or changing project specifications. It is essential that project stakeholders understand the different forms of variation orders and their respective implications in order to manage and minimize the impact of these modifications.

Table 3.3: Types of VOs and their effects

Variation Order Type	Description	Effects/Implications
Design Changes	Changes on design, plans, materials needed	More time needed to coordinate new objectives. More time for approval procedures. Additional costs for design changes, materials.
Scope Changes	Additions or changes on the existing ones	The level of complexity of the project will increase. Additional resources might be necessary. Problems with cost and labor allocation. Great impact on schedule and project final duration.
Quantity Changes	Increase of quantity for materials needed, change in labor needed.	Additional procurement procedures. Additional costs as a result of the above. Impact on budget and cashflows. Scheduling changes and resource allocation.
Specification Changes	Additions in technical details or increased performance	Modifications on the labor and technique of work. More quality inspection. Failure to meet the new goals and objectives. Cost and timeframes will be affected.
Contractual Changes	Changes in terms of the contract, timelines, prices, risk management.	Disagreements between stakeholders. Financial and legal implications. Impact on profitability, payment schedules. Risk management problems. Impacts communication and collaboration.

3.3.1 Design Changes

Variations and changes in designs refer to modifications and revisions made to the original designs and initial plans. These variations can be applied at any stage of project implementation. Some of the variations to be performed may be impossible or very difficult to perform. These present many challenges that affect various aspects of the construction process.

- **Revisions of the original designs and plans**: if it will be necessary to make changes to the design, there will be a need for changes to the architectural, structural, mechanical, and electrical plans. All these should be updated according to the necessary modifications. This will also result in changes to the organization of the work, but it may even lead to a change in the overall goal of the project.

- **Material requirements**: changes in design may also require new materials. These materials may even be completely different from what was originally planned. As a result, this will result in delays, as new procurement processes will be carried out to secure the materials. Also, it will take more time for the construction team to get used to these materials and continue working normally.
- **Coordination**: since many changes cause a very complicated situation, this will also affect the coordination between the parties involved in the project. The entire construction project is a highly intertwined web between the parties and cannot move forward unless there is effective communication between them.
- **Necessary steps to approval of variations**: each variation requires a separate procedure to be approved. All parties such as clients, architects, engineers, local authorities, etc. should be included in these approval procedures. These approval procedures can be very lengthy but at the same time very bureaucratic. Here we can also include changes in the contracts between the parties, which can bring many disputes and delays.
- **Significant cost overruns**: cost overruns may include the costs of new materials, designer fees to rework the design, or even new equipment that may be needed.
- **Demolitions and re-designs**: re-designs and changes in design may also require the demolition of the building up to a certain stage. This includes costs for demolition debris and reconstruction. Like the above factors, this also causes delays in the completion of the project.

All the above factors affect the overall goal of the project. During the application of changes, the boundaries of the project will gradually expand beyond the original scope. In order to minimize design changes, a proactive management method should be applied. Here we can mention the development of detailed studies, detailed planning, the promotion of effective communication between parties and the creation of plans and strategies to manage unexpected changes. Also, keeping a budget and a flexible time frame that takes into account possible design changes should be considered.

3.3.2 Scope changes

Changes in scope relate to the addition of new elements or to changing the core purpose of the project as a whole. These changes affect the complexity of the project. Changes in the main goal increase the level of complexity as it makes project management a challenge. A review of all plans will also have to be carried out, working for the coordination of the parties.

Additional resources are another important factor. When the main purpose changes, the need for additional materials or their change will arise. Furthermore, this whole situation will also affect the interruption of work and consequently the initial deadlines of the project, significantly increasing them. At the same time, the probability of mistakes made by the construction team and also by other stakeholders will increase.

Quality is another important aspect. This should be given a lot of attention as applying changes to the main goal will cause the construction team to work under pressure to meet deadlines. This will then result in limitations in attention to detail and quality control. Also, when the main purpose changes, the client's expectations must be managed more carefully. This is always a very important factor when the purpose changes. To manage changes to the core goal effectively, clear communication and documentation are critical. Regular updates on project status and communication of these changes to stakeholders ensures that everyone is well-informed about the changes and their impact.

3.3.3 Contractual changes

Contractual changes in construction projects relate to revisions or modifications made to the terms of the original project contract. It includes modifications of deadlines, clauses for risk management strategies, materials, or responsibilities of each party. Some of the reasons why these changes may occur are customer requirements, unforeseen circumstances, scope strategies, etc. Contractual changes will also result in modifications in financial (including financial benefits and degree of liquidity), legal and managerial issues. This is because it is necessary to do a total review of the responsibilities of each party. These will also extend project timelines, which can therefore have a substantial impact on overall project dynamics.

A contract concluded between the parties must be clear. It should very well describe the roles and processes for handling modifications. At the same time a very precise procedure must be developed to manage the changes. All procedures must be documented and communicated in a timely manner. Legal experts should be selected with a high level of professionalism as their advice as needed ensures that contractual modifications are in compliance with applicable laws and regulations. Maintaining a flexible budget and financial planning to accommodate anticipated contractual changes will positively impact the project's financial stability and favorable relationships with stakeholders.

3.4 Complexity of VOs, cost overrun, duration and project size

Variation orders can be of different levels. Depending on the dirty types of modifications (from the simplest changes to the most difficult ones that change the very essence of the project) that are required, the level of their complexity will be determined. But what are some of the factors that are affected by these orders and the level of complexity. This table examines the variables that will be analyzed in the following sections through the regression model.

Table 3.4: VOs, cost overrun, duration and project size

Variable	Key Impacts
Impact on Overrun Cost	This entails changes in the basic scope of the project. As a result changes in allocation of resources will be necessary. Complexity of VOs can also impact the way the cost are calculated, which can be a new challenge for the stakeholders.
Impact on Duration of the Project	High level of complexity will require more additional time to analyse the changes in cost and timeframe until project is completed. Different matters will need to be addressed, and that means costs, techniques, technology etc.
Impact of Project size on Complexity of Variation Orders	Larger projects need more discussions and new objectives. New strategies for risk management will also be necessary. More stakeholders are part of the project, it might also cause problem with communication and collaboration.

CHAPTER IV

ANALYSIS OUTCOMES

Variation orders have a very significant impact on construction projects. As a result of the changing environment in the construction industry, there is more and more variation orders. These changes bring the need for modifications of various categories in projects which have an impact on the entirety of the project and most importantly on their total cost. In this chapter, 30 projects will be considered. Through their numerical and qualitative data, we will draw a conclusion about the impact of variables on the total cost of construction projects and we will also discover relationships of other variables related to these projects.

Through descriptive statistics, we will examine the trend of projects in relation to their anticipated costs and their final costs. Next, we will see a graphical comparison and analyze the projected project completion deadlines and the final project completion deadlines. Meanwhile, through regression, we will understand how the independent variables affect the dependent variables in terms of construction projects.

4.1 Methodology

The methodology of this study is a combination of descriptive statistics and statistical regression model. Through descriptive statistics we will reflect on a trend of these projects in terms of anticipated costs and their final costs. At the same time, we will also examine the estimated deadlines for the completion of the projects and the final deadlines, that is, how long it took to complete each project. Descriptive statistics will be examined later in this chapter in various graphs.

Meanwhile, the second analysis method of this study will be the statistical regression method. The analysis will be performed through linear regression and multiple regression. This method is used in almost every field as it is formulated in such a way to draw conclusions about the relationship of different variables, but at the same time also about the nature and strength of these relationships. Usually, this model has a dependent variable (which is denoted by Y) and one or more other variables that are defined as independent (which are usually denoted by X1, X2, etc.). So, expressed in a simpler way, this model helps us to infer how the independent variables (X) affect the dependent variable (Y).

From the regression model we will get an equation. The equation allows us to estimate and examine the coefficients, to assess the strength of the relationship between the variables considered. These coefficients also provide opportunities for predictions and help us to test the hypotheses placed on the variables. Also, the results of the model contain data related to the suitability of the model to carry out the study of the variables and the relationship between them.

In the multiple regression method, the following variables are taken into consideration to conduct the analysis:

- Independent variable (X1) – final project duration
- Independent variable (X2) – variation order complexity (on a scale of 1-5)
- Dependent variable (Y) – overrun cost of the project

It is important to clarify that the data for these projects are non-public and confidential data. For this reason, the projects are named through numbers. As for the complexity variable of the variation orders, the complexity scale is set from 1 to 5. The number 1 represents the lowest complexity associated with them, while 5 represents the highest level of complexity. The level of complexity for each project is determined by taking into consideration the requirements for design changes, technical changes but at the same time also the experience as a whole with the work of the project until its completion.

The second regression analysis considered the size of the projects as well as the complexity of the variation orders. More specifically:

- Independent variable (X) – project size (expressed in m2)
- Dependent variable (Y) – complexity of variation orders.

4.1.2 Limitations of the Study

The approach of this study combines descriptive statistics and linear regression. The variables for the linear regression model are final total cost, estimated duration, final duration, complexity variation orders, project size. Other data were analyzed through descriptive statistics.

The sample size for this study is 30 projects. Regarding these analyzes and the study as a whole, there are some restrictions and limitations.

Data collection: as we mentioned, the analysis was carried out on 30 construction projects. The data is not public and is sensitive. For this reason, the projects are named through numbers. The data we have available for this study, for the 30 projects, are: estimated total costs, final total costs, estimated durations, final durations, complexity of variation orders, project sizes (measured in square meters) and contract types.

Confidentiality: the data collected for this study is considered non-public and confidential. Naming projects with numbers ensures anonymity and confidentiality. However, it may impose limitations on the ability to cross-check or verify data with other sources. Furthermore, other researchers who may have an interest in the issue and want to conduct similar studies may not be able to undertake site-specific studies. They may also have difficulty understanding possible regional variations due to the lack of precise project names or locations.

Sample size: one of the disadvantages of this study is the relatively modest sample size of 30 construction projects. This size may not adequately represent the diverse nature of the construction sector. Consequently, the conclusions drawn from the statistical analysis may not be very significant. When the sample is larger the results provide greater certainty and researchers can generalize on those results. Considering only 30 construction projects, there is a risk that the distinctive features of individual projects affect the overall results.

Subjectivity on the degree of complexity of variation orders: the level of complexity is set on a scale from 1 (one) to 5 (five). For this aspect, a clear analysis has not been carried out on how to determine this rate and allocation for each project. The subjectivity of this scale increases the probability of bias. Many individuals and professionals may interpret the complexity of variation orders in a completely different way. Consequently, there is a possibility that this may lead to data inconsistencies.

Variables considered: the study focuses only on some characteristics of the project. Despite the fact that these variables are very important to projects, there are many other variables that can play a role in their progress. As there are other external factors such as weather, economic volatility, and regulatory changes, it should be considered that not including these factors limits the comprehensiveness and analysis.

Applicability: the monster size and limited project data may make the analysis not applicable to the entire construction sector. The construction sector is very diverse, and projects can have many differences between them in terms of purpose, complexity, location, etc.

4.2 Descriptive Statistics

A construction project has many components and factors that affect its effectiveness. These components make it difficult to calculate with certainty its final costs. Of course, the final costs and the preservation of the objectives set at the beginning of the project, convey of a high effectiveness of the project, but this is almost impossible to achieve. At the end of the project, after a comparison is made between the anticipated and final costs, it is noted that many factors have influenced its increase. These factors may include materials, labor cost, variation orders that were necessary, etc.

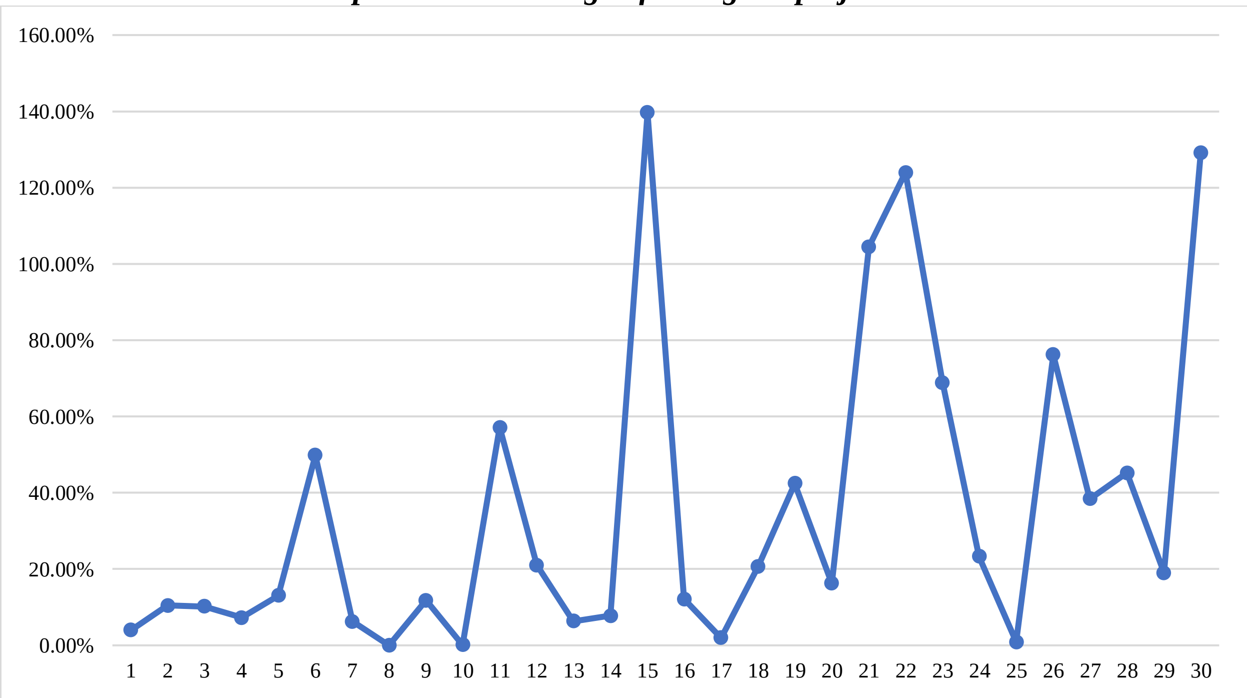
In order to achieve a satisfactory result and to ensure the smallest possible difference between the estimated and final costs, it is important that project managers follow the most effective procedures and monitor the progress of the project periodically and as often as possible.The graph below represents the percentage differences between the final and estimated costs for the 30 projects we are studying.

4.2.1 Predicted and final project cost of the project

Cost estimating is the practice of projecting the financial resources that will be needed to effectively complete a project. This analysis is very essential as it serves as the basis for budgeting, resource allocation and financial control throughout the life of the project. When this analysis is done properly and accurately, it not only ensures that all parties involved in the project have a realistic view of the financial scope and overall costs, but also enables them to make more accurate and informed decisions while minimizing potential risks at the same time.

Cost analysis and estimation contributes to ensuring the appropriate level of funding, minimizing cost overruns, and completing projects on schedule and on budget. Furthermore, an accurate estimate of the necessary costs improves the feasibility estimates of the project and promotes the improvement of its planning and execution until the last stage. Finally, since the construction industry is very complex, these assessments are very critical to the performance and sustainability of construction projects, allowing companies to maximize their investments and meet project objectives safely and efficiently.

Graph 4.2.1 Percentage of change in project cost



After analyzing the data for our 30 projects we can come to some conclusions. First of all, it should be clarified that the projects are of different sizes and as a result of that fact there is great difference between the estimated and final costs depends on this fact. However, we conclude the following regarding the data:

✓ Some projects have very low variances compared to some other projects. For example, we can mention a project which has no difference in final costs, but meanwhile we have projects that manifest a difference of 0.09 percent, 2 percent. These cases prove to us that construction projects can achieve their objectives even while maintaining a very small difference between the final cost and the predicted one.

- ✓ Just as there are projects whose effectiveness is reached in terms of costs, there are also more complicated projects. For various reasons, the figures can reach 139.64 percent, 123.99 percent, and 129 percent. Referring to these changes in percentage, we understand that the cost has been exceeded at very high levels contrasting them with the anticipated outcome. These important changes can also be an indication of how difficult it is in certain instances to make accurate predictions regarding the costs of construction projects.
- ✓ Another significant finding is that construction projects are complex in very different ways. In light of this, it becomes even more difficult to predict with 100% accuracy what will be the projected extend of the overall cost.

4.2.2 Probable factors contributing to cost variability

The construction industry is very complex and, in many cases, the estimated total cost deviates significantly from the total final cost. This proves to us that there were many mistakes in the calculation of the initial cost. There are several factors that can result in errors of this type:

i. Poor and inappropriate planning (for the complexity, size, or other factors) of the project results in the underestimation of costs until its completion.

ii. A failure to account for various costs associated with the project such as relevant building permits, legal fees, or other costs of this nature.

iii. A poor survey of the market situation: this can be related to both the competition and the costs of the materials needed for the project.

iv. Failure to analyze previous projects: of course, very important knowledge can be gained from experience with previous projects, both materially and managerially. By not relying on these experiences at all, it is likely that inaccurate calculations will be made.

v. Scope changes: Projects with large scope changes are likely to experience significant cost fluctuations. The following variables may have influenced the scope changes:

vi. Changes in the main goal also have a lot of impact. This may be related to additions or modifications that may be requested by customers, changes in regulations or legal framework, changes in design, etc.

vii. Unforeseen circumstances include factors such as climatic conditions, possible accidents, material costs (especially their increase), supply chain disruptions, material shortages or unforeseen price fluctuations.

viii. Market: changes in material costs, labor rates, economic conditions, etc., are factors that affect the project in general. This includes market volatility and labor supply and demand. Inflation is another factor that affects overall project costs.

ix. Project size: when small, projects have more predictable costs than larger, more complex projects. Large projects have more complex procedures, and the risks are higher.

Conclusion: In general, the data reveal that cost fluctuations are caused by several factors at the same time such as risks, unforeseen circumstances but also the size of the projects. Addressing these issues can positively contribute to more accurate forecasting and more effective control of project costs in the future. Professionals who are responsible for projects must be able to perform different analyzes from multiple aspects in order to predict project costs more accurately. By formulating explicit goals and challenges they may face during the execution of the project, they will be able to address them effectively. Drawing up a detailed plan for each stage of the project will enable a more precise estimation of the costs managers will encounter.

Suggestions for improving cost estimation and control:

- Detailed project planning: this is one of the main causes of cost overruns. Critical factors must be assessed, and a comprehensive project scope analysis conducted with all parties involved to achieve a thorough understanding of the project's objectives and needs. Expert opinion is also very important at this stage. A complete structure of how the work will be divided must also be created.
- Adequate analysis of potential risks: it is necessary to make a systematic risk assessment. At the same time, approaches and strategies that are adequate to address them should be designed, in order to reduce their impact on project costs. A percentage of the budget should be allocated specifically to this factor.
- Periodic monitoring: a reliable cost tracking system should be used. This system will record all expenses comparing them in real time with the planned costs. Continuous analysis should

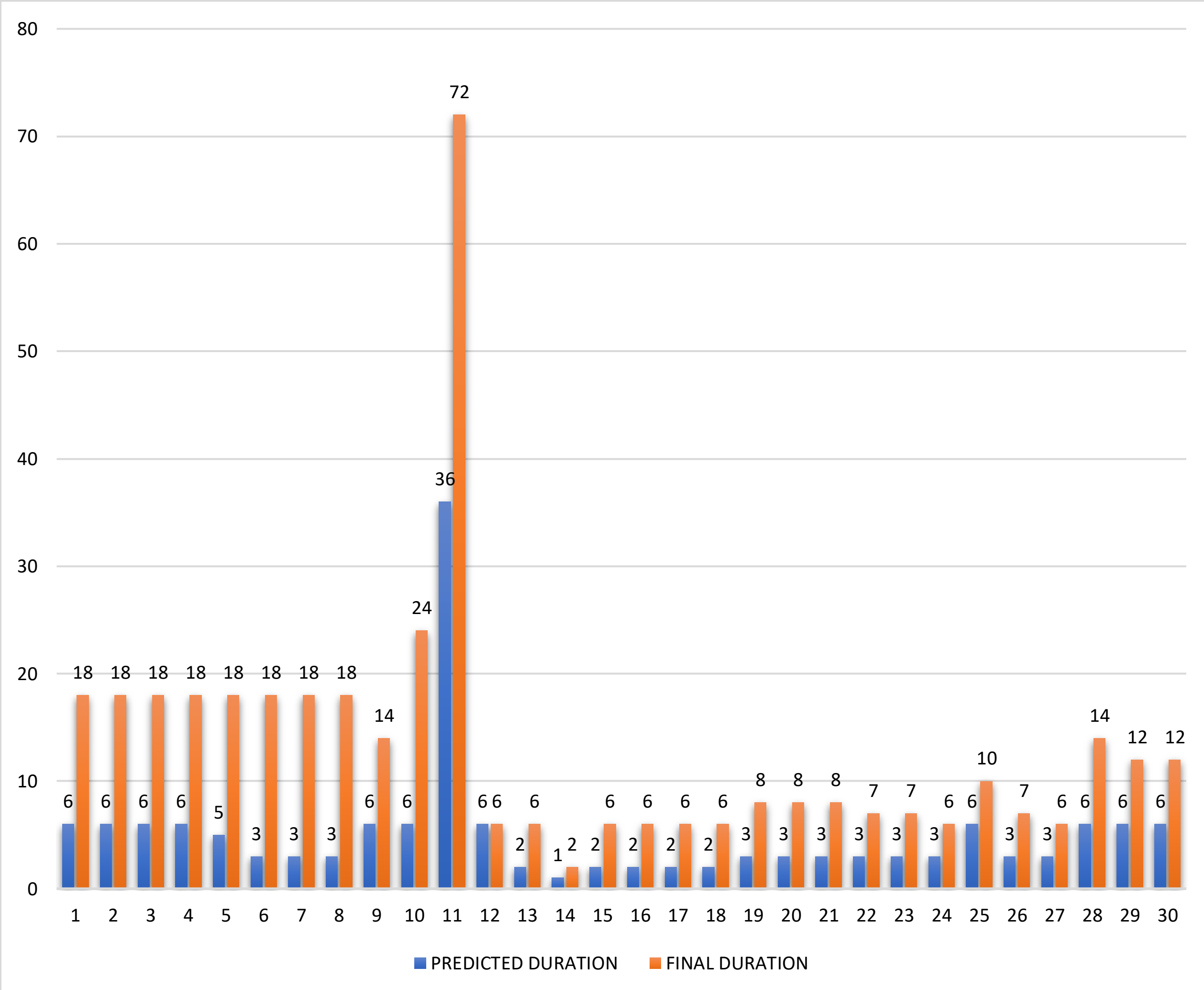
be carried out, especially during periodic project progress meetings. In this way, the financial health of the project can be analyzed more easily, and any possible deviations can be detected

- Performance analysis: the EVM approach can be applied to monitor project performance, compare expected progress with actual progress, and forecast final costs.
- Analysis of historical data and previous projects: this greatly affects the underestimation and underestimation of costs. A database of expenditure and results of previous projects should be maintained. Today there are many analytical programs that can help analyze past projects to find trends, patterns, and common cost factors.
- Hiring experts: managers find it impossible to perform an accurate calculation of costs without the help of experts. One should cooperate with them for cost estimation and control.

4.2.3 Predicted and final duration of the project

Predicting the timelines needed to complete a construction project is one of the most important objectives. These deadlines are very essential as they relate to most aspects of the project such as operational expenses, how the resources that are available will be distributed, or overall, for its successful completion. Many projects in this sector go beyond the forecasts in terms of deadlines and this is one of the characteristics related to the specific field of construction. Large discrepancies in anticipated and final deadlines result from many project-related variables. For these reasons, it is necessary for professionals in the sector to carry out detailed analysis in order to compile a detailed and explicit framework of the dynamics associated with a given construction project.

Graph 4.2.2 Predicted and final duration of the project



The graph above reflects the anticipated deadlines and the final deadlines related to the 30 projects that are the subject of this study. This graph clearly states that these projects have faced very significant changes in project deadlines. In most of the projects, the final deadlines significantly exceed those foreseen. A concrete example are the projects that were predicted to last only half a year, but in the meantime, they required a deadline of 18, 24, or even 72 months to complete. These delays can be for many reasons. Importantly, they provide evidence of low-efficiency and low-efficiency projects.

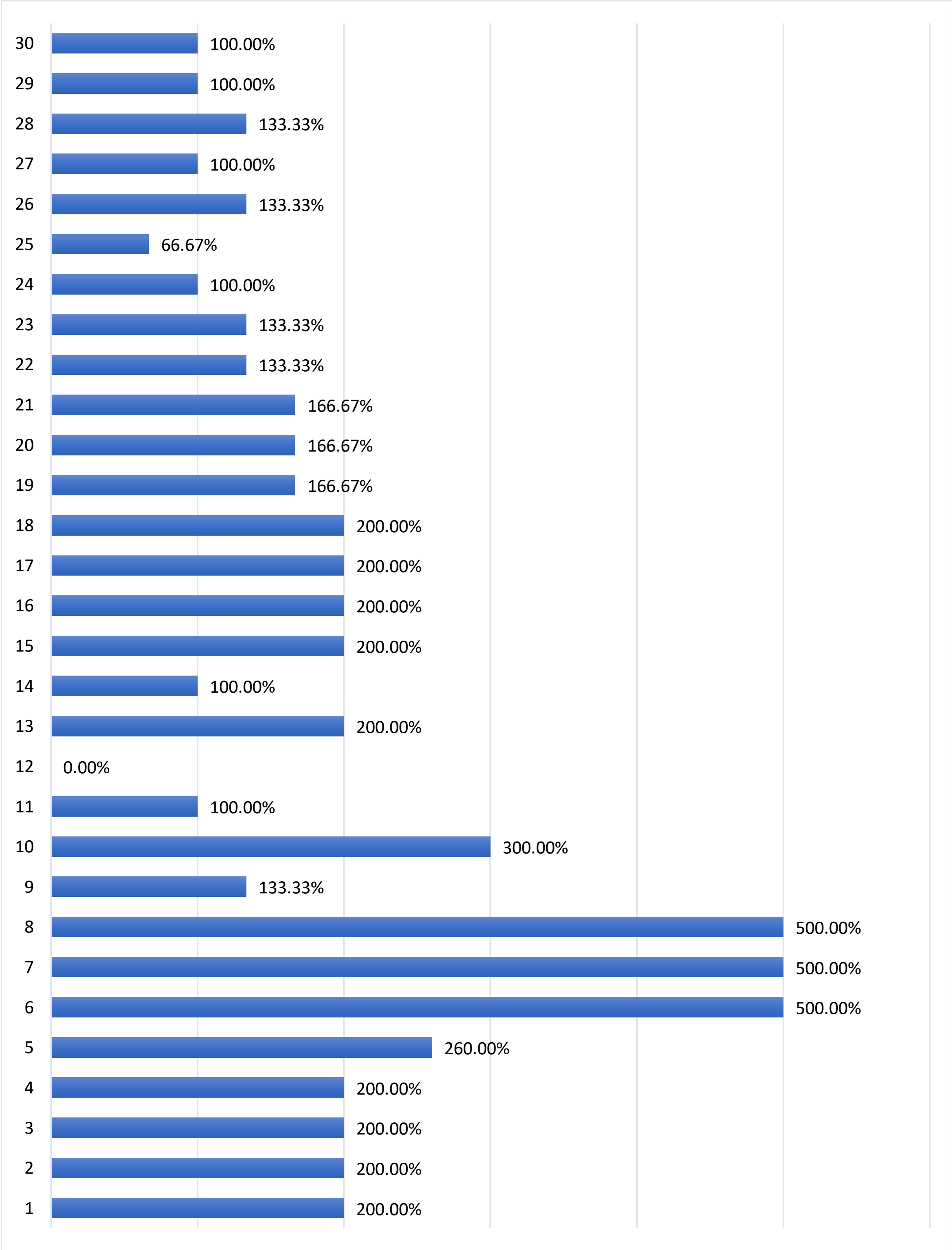
However, there are also projects that are completed within the anticipated deadlines. These projects constitute a very small number compared to those projects that have significantly exceeded their deadlines. This data proves once again how complex construction projects are and how difficult it is to accurately predict the duration until their completion. In addition to other important variables, it should be noted that there are other factors that can affect the duration of the deadlines. This may also include the legal framework of the country where this project is being developed, the climatic and weather conditions, the resources that the projects have available, or the techniques related to the way the project is managed.

In order to avoid these significant changes in the forecasts made at the beginning of the project, it is necessary for the professionals involved to manage its progress as efficiently as possible. Regular and continuous monitoring is also very necessary. Project managers must be able to assess the situation at each stage of the project and make immediate decisions to minimize time and cost overruns.

Percentage of change between Predicted and Final duration

Accurately estimating the deadlines for the completion of a project is a very important part of its effective management. If the planning and allocation of resources is done well, it will be easier to respect the anticipated deadlines. In the following section we will examine the percentage difference between the project duration estimated at the beginning of the project and the final one. It will further reflect some practical insights on how managers can improve their planning procedures and limit the risks associated with significant variances between projected and final project completion dates.

Graph: Percentage of change between Predicted and Final duration



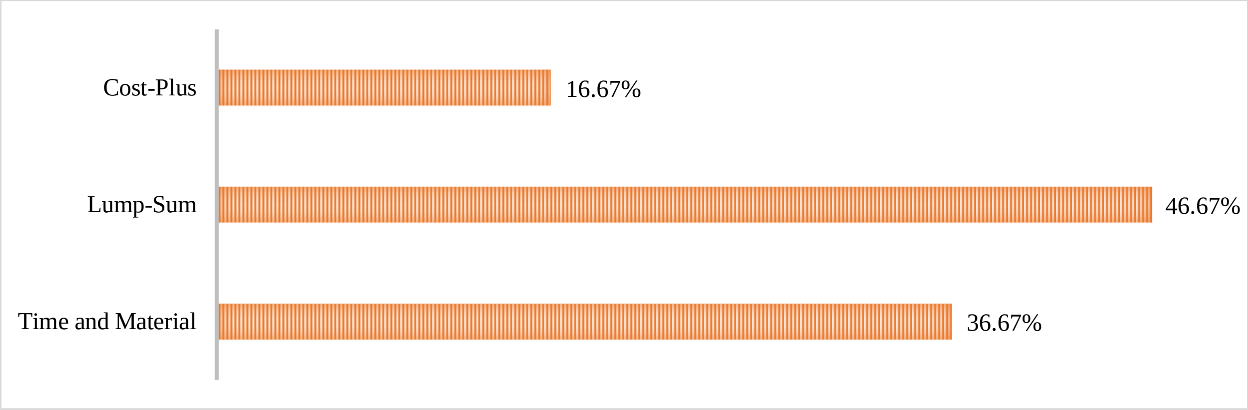
The data available to us speak of a variety of delays in project completion deadlines. Some of these projects have required a doubled time frame compared to the initial one. But the worst is that some of them have gone up to five times the deadlines. These large overruns prove that there was poor project planning, ineffective execution, misallocation of resources, or unforeseen obstacles that may have impacted. Exceeding these levels can result in higher costs, additional resources, but also contractual conflicts.

However, it should be noted that not all projects had delays in such large numbers. Some of them managed to complete the project ahead of schedule, demonstrating excellent planning and execution. But still, this is a very small number compared to those projects that have significantly exceeded the deadlines. A team that is in charge of the project must prioritize accurate forecasts, risk assessment and proactive management. In this way, it will be easier for them to reduce delays and ensure a simpler execution of the project. Regular monitoring, flexibility in management and planning and an effective contingency management approach can help deal with unexpected setbacks and minimize disruptions.

4.2.4 Contract types and issuance time of VOs

The percentages presented in the graph below indicate that lump-sum is among the most widespread contracts. They are followed by time and materials and finally cost-plus contracts. Lump-sum contracts indicate that most projects are based on fees and prices as well as a predetermined scope. These conditions provide a cost calculation which is fixed and considered more transparent and offers a higher level of security.

Graph 4.2.3: Contract type

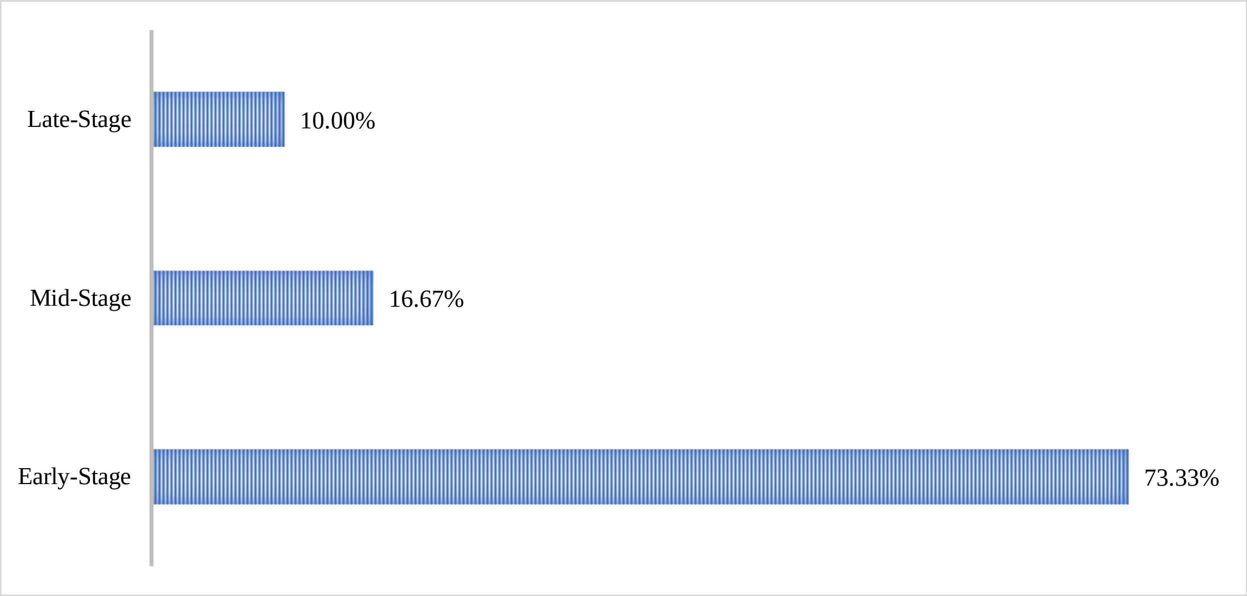


These data suggest that the parties involved in projects prefer to engage in a project that has explicit and clear objectives. In such a manner they also avoid a high cost overrun of the project. Meanwhile, time and material contracts mean invoicing the project based on working hours and at the same time the materials used. These contracts have more room for flexibility and tend to see the project through to completion. Nevertheless, it is necessary to point out, that there are projects that need such a contract, since each project has its own characteristics and can be faced at any stage with any need for changes or additional materials.

Finally, cost-plus contracts are more befitting when the project objectives are not clearly defined. In light of the data presented at the above graph, we conclude that the projects that are the subject of this study were more inclined to establish precise strategies. Lump-sum contracts basically mean that most project managers put more emphasis on managing overall costs while prioritizing the reduction of the project's financial risk. What is important is that project managers have a proficient grasp of what type of projects they are facing. By establishing a clear understanding of the overall project framework, they will be able to better evaluate the type of contract that is most suitable and most effective and profitable for all parties involved.

The stage at which variation orders are issued in construction projects is very essential to the effective management of a project. As has been clarified in the previous sections, a variation order consists of changes to the objectives defined at the beginning of the project. Given that the impact on the overall progress of the project of these orders is considerable, it becomes essential to analyze in depth how these orders are distributed during the implementation of the projects. If a manager is capable of understanding the consequences of the variation orders that are undertaken, it will be easier enhancing the overall project efficiency and simultaneously significantly reduce the financial risk of the project.

Graph 4.2.3 Time of issuance of VOs



The statistical data related to the stages when the variation order was issued are as in the chart above. Specifically: the early stage is about 73 percent, the middle stage is about 17 percent, and the late stage is 10 percent. These data prove that the actors involved in the project work effectively and actively monitor when the project needs changes, without letting it continue to a later stage ineffectively. By taking measures to address the needs for changes at an early stage, excessive costs can be avoided, but at the same time it leaves room for discussion with the parties involved. Consequently, it also affects the creation of better relations between partners.

For projects that required changes in the middle phase, we can argue that this need was discovered in a middle phase of its implementation. However, this number is small, and this is a positive indicator. These necessary modifications may also have come as a result of not clearly defining the objectives and strategies at the beginning of the project. Although there are very few projects for which variation orders have been issued at a late stage, it is worth noting that at this stage stakeholders must be more cautious as it always coincides with a significant cost overrun. This is because the work is almost finished and if there will be changes, they will be applied exactly to a work that is already complete.

These details emphasize the need for effective communication between all parties involved in the project in order to reduce unnecessary costs and minimize variation orders.

4.2.5Potential causes of project delays

Project complexity and size: based on the data we have available; we conclude that projects with greater complexity and larger size are more likely to experience delays and extensions of initial deadlines. When we talk about the level of complexity, we relate it to the technical difficulties of the project. When projects are large, they have many activities and more interactions between teams. In this case, interdependence is essential, making coordination and execution somewhat difficult. Such projects need meticulous planning, specialized skills and effective management in order for the project completion to best match initial projections.

Recommendation: in the early stages of a project of high complexity and size, it is very essential to carry out extensive feasibility studies. The level of risk must also be correctly analyzed. Next, another very important aspect is the proper planning and distribution of resources. The project should be divided into phases that are easily manageable. Each of these stages should have very clear objectives. At the same time, monitoring and reporting strategies should be created in order to ensure the effective progress of the project and to resolve the difficulties that may be encountered.

Type of contract: according to the available statistics, the contracts that had the largest discrepancies between the expected duration and the final one are "time and material" contracts. These contracts offer more flexibility and are more accepting of variation orders. However, they can result in a very high overrun of the initial deadlines.

Recommendation: when construction projects are decided to operate through "time and materials" contracts, they should set very high limits and limits for the management of variation orders. All necessary modifications must be analyzed in detail, in terms of their impact on the project. This applies to the impact on timelines but also in terms of the budget.

Available resources: projects with limited resources (in people, materials and cost) may have more obstacles and delays. Lack of resources can hinder the progress of the project.

Recommendation: in the planning phase, a full assessment of resources should be done to identify the gaps and the possible circumstances that could lead to these shortages. The project team must have access to the general information of the project but also to the resources that this project has available. Each party can offer recommendations for improving the situation and alternative solutions that can positively affect the achievement of the overall goal of the project. One way in which delays can be reduced is by optimizing the allocation of resources and creating contingency plans for unexpected resource shortages.

Contingencies and external conditions: since we do not have much information on external issues such as bad weather or the specifics of the changes made, we can only state that these are also factors that have a significant impact on construction projects.

Recommendation: plans must be drawn up that manage project risks, including external factors. Project plans should have a clause that allows for planning flexibility to account for unforeseen delays caused by external factors.

In conclusion, the analysis of the possible reasons for exceeding the initial deadlines for the realization of the project, emphasizes the importance of detailed planning, good contract management, optimal distribution of resources and proactive risk assessment. Projects with a high level of complexity, a significant size and with "time and materials" contracts, need extra care to ensure completion on time. Project stakeholders can improve time management, minimize the risk of delays, and increase overall project performance by using appropriate project-appropriate tactics and best practices.

4.3 Analysis of contract types

Analysis of contract types in construction projects is a very important factor for project management. Following this section, we will examine each of the contracts, to analyze the advantages and disadvantages they present. Analysis will be performed against variation orders.

4.3.1 Cost-Plus contract

Advantages:

- In this contract, in addition to being compensated for the expenses incurred, the contractor also has a certain profit on the expenses. This is a good incentive for contractors as they take the initiative to manage the project effectively.
- As a result of the payment structure, the contract is very flexible to changes needed during the project, as the required changes can be implemented quickly and efficiently.

- This contract also helps attract qualified contractors for complex or high-risk projects. This is because the contractor has a higher certainty over costs and profits. These make the contract very attractive, especially in cases where the project has many anticipated challenges.

Disadvantages:

- Considering the fact that this contract is very flexible, there may be an incentive to make as many unnecessary changes to the project as possible in order to increase his profit.
- The lack of a clear spending limit can lead to very high project costs and the risk of going over the initial budget significantly. Because of the financial incentive that this contract offers, some contractors may have a tendency to incur unnecessary expenses.

Conclusion: these contracts offer a very important advantage when it comes to many unforeseen changes, as usually happen in projects with a high technological level and especially in projects where there is no complete information or predictions about how its progress may be . When it is not possible to perform an analysis to fully predict the needs of the project, the flexibility that these contracts provide is very useful. However, measures should be taken to avoid unnecessary expense and abuse of change and variation orders.

4.3.2 Lump-sum contract

Advantages:

- This contract provides ease of management as the total cost of the project is decided by the parties involved in advance. This brings a higher level of transparency and higher security for the one who owns the project.
- Changes necessary during the execution of the project do not affect the total cost of the contract. If variation orders need to be issued, the contractor is obliged to cover any additional costs resulting from the applied changes.

Disadvantages:

- If the project is not well planned and if at a later point many changes are needed, the contractor may make minimal profit or even suffer a loss, as he has to cover the cost of the changes if they exceed the estimated cost.

- Lack of flexibility can result in long discussions and tensions between the parties to find a suitable solution to the changes. As a result, the necessary changes will be made very late and will extend the project deadlines.

Conclusion: these types of contracts are suitable for projects that have a higher level of security and a lower risk. This means that the objectives must be well defined and match the total cost of the project. If these conditions are not met, this type of contract is not advisable, especially in cases where numerous changes or unforeseen circumstances are expected.

4.3.3 Time and material contract

Advantages:

- This contract offers a higher level of flexibility for changes and variation orders. The work performed and the materials in this contract are paid according to the time spent and the quantity used. This makes this contract very suitable for projects with frequent and unpredictable changes. In this form, variation orders are easier to manage.
- The party who owns the project has more control over each phase of the project. They only pay for the labor and materials that were used.

Disadvantages:

- If there is a lack of control and good management of time and materials, the project can run over budget and deadlines at high rates.
- The risk associated with additional costs falls solely on the project owner, as he is responsible for the unforeseen expenses caused by the necessary changes.

Conclusion: these types of contracts are best suited for projects that require frequent changes and are difficult to predict. The contract offers flexibility to better adapt to needs, however conditions must be created to monitor expenses well and minimize additional costs that may arise from changes.

In conclusion, the choice of contract type is an important decision for the management of construction projects. All parties involved should carefully analyze their project and at the same time analyze the advantages and disadvantages of each type of contract. In this way they can understand which contract is most suitable for their project, depending on the changes that may be applied later. Managing change effectively affects the overall success and efficiency of the project.

4.4 Multiple linear regression

The following table illustrates the ANOVA table of multiple linear regression. As indicated above, this model will analyze the relationship that exists between additional costs of projects, the level of complexity of variation orders and the final deadline of projects (expressed in months).

The ANOVA table, or otherwise called analysis of variance, is one of the results we get from applying linear regression. This table gives us a summary of the model we have applied and is also used to see if there are significant differences between the means of the variables. The table contains many elements, but in the case of our analysis, what is important is the level of significance. When the regression model is applied to a study, a confidence level is also determined at the same time. This confidence level indicatesthat there is always a margin of error in the model's results. Confidence levels that are commonly specified in the regression model are 90 percent, 95 percent, and 99 percent. In the model below, the 95 percent confidence level is taken. This asserts that there will be a margin of error equal to 5 percent. The level of significance is also called the p-value. To conclude that the model was valid for the study of the relationship of the variables, this value should be less than alpha = 0.05.

Table 4.3.1: ANOVA Table

	df	***SS***	***MS***	***F***	***Significance F***
Regression	2	3,1110	1,5555	56,665	0,00000
Residual	27	0,74117	0,0275		
Total	29	3,8522			

The significance level defines the threshold below which the F value is considered statistically significant. In our case we set a significance level equal to 0.05. This implies that the p-value must be less than 0.05 in order for the result to be considered significant and valid. Thus, to provide a more concise and lucid explanation, this value further substantiates the primary conclusion on the importance of the model to carry out the study, on the relationship of our variables. The p value in the ANOVA table is very small, almost 0. This conveys that the p value is less than the alpha value, which automatically makes the regression model significant and valid for the study.

On the following section we will examine the table of coefficients. Theoretically, the coefficient is related to the change in the average response of a variable. However, this is the case when other variables or indicators in the model remain constant. The negative or positive coefficient represents the direction taken by the relationship between the independent variables and the dependent variable. As it is mentioned above, the value of the coefficient has an important role in determining the strength of the relationship between the variables. However, despite this being a good indicator, the most statistically significant value remains the p-value. Despite the fact that in the summary of the model in the ANOVA table, we have a p-value that conveys for the model as a whole, in the table of coefficients we also have a p-value for each of the studied variables.

4.4.1Complexity of variation order: Counterintuitive findings

Based on the results of the regression model, considering the p-value and confidence intervals, it became clear to us that the complexity of the variation orders did not have a significant impact on the project cost overruns. Based on the value of p, for the variable of complexity of variation orders, which is 0.16 and is greater than the alpha value (0.05), we proved that there is no statistically significant relationship between variation complexity and cost overruns.

At first glance, these results may seem very contradictory, since logically, variation orders are an important factor that affects cost overruns. However, there may also be cases where they do not affect. This can be related to many reasons that explain why this result contradicts previous knowledge in the field of construction projects. Some of these reasons may be as follows:

- **Good project management**: managers may have used effective methods to address various issues. They may also have used very good approaches in handling complex variation orders efficiently. Given this is also the level of complexity, they may have issued orders that are more manageable.
- **Variation mitigation techniques**: by efficiently allocating available resources, managers have managed to mitigate the effect and complexity of variation orders.
- **Appropriate allocation of risks**: managers may have found ways to spread risks through different deals and parties. In this way they may have minimized the direct impact on project cost overruns.
- **Experience and expertise**: prior experience and information enables managers to react quickly and efficiently in managing variation orders.
- **Limitations in the study**: it is very essential to acknowledge that data and study methods always have limitations. Even in this case, the study is limited as it is limited to only 30 projects. Limited monster and project characteristics can also affect its limitation. Here we can also include the fact that those features that are not included have a greater impact on cost overruns.

In conclusion, our study sample showed us that the complexity of variation orders has no substantial impact on project cost overruns. But even though this result is not in accordance with the general notions of this field, we have to think that the construction industry is very complex. Being complex, each project has its own characteristics and any factor, no matter how small, can have a reaction that may not be expected. What this study highlights is the need for effective management as well as the need for additional research and refinement of cost estimation and control models to capture all relevant factors affecting construction projects.

4.4.2 Interpreting F-value

The F value is a statistical indicator used in the regression model to analyze whether the regression model explains the relationship between the independent variables. In our case this value will tell us if there is a relationship between the complexity of the variation orders and project deadlines) and the dependent variable (cost overrun. What this indicator does is evaluate the overall importance of the model by comparing the variability explained by the model (Mean

Square Regression, MSR) with the variability that is not explained by the model (Mean Square Residual, MSE).

The formula for calculating the F value is F = MSR / MSE

MSR (Mean Square Regression): MSR reflects the variance explained by the regression model. It results by doing the regression sum of squares (SSR) and dividing it by the number of independent variables in the model (df_regression[1]).

In our case, the MSR is calculated as 3.1110 / 2 = 1.5555.

MSE (Mean Square Residual): MSE talks about the unexplained variability in the data, otherwise known as residual error. It is calculated by taking the residual sum of squares (SSE) and dividing it by the residual degrees of freedom (df_residual[2]), which is the total number of observations minus the degrees of freedom and the intercept (df_residual = total observations - df_regression - 1).

In our case, the MSE is calculated as 0.74117 / 27 = 0.0275.

Interpretation of F value: The F value is used in hypothesis testing to assess whether the regression model is statistically significant to analyze our data. This value compares the MSR to the MSE, giving us an F value of 56.665.In case the F value is more than one, it means that the model explained variability (MSR) is greater than the unexplained variability (MSE). In other words, the model reveals important information about the independent and dependent variables.

Next, the F value will be compared to the significant F value (otherwise called the p value). The latter will be set at a limit that is predetermined in the analysis (which can be 0.05 or 0.01).The results of the model show us that we have an F value of 56.665. This value tells us that the model is highly significant. The chance of achieving such a large F-value by chance is almost zero (F-significance = 0.00000).

[1]The degrees of freedom for regression represent the number of independent variables (predictors) included in the regression model. In simple linear regression with one independent variable, df_regression would be 1. However, in multiple regression with more than one independent variable, df_regression is equal to the number of predictors.

[2] The degrees of freedom for the residual error, also known as the degrees of freedom for the residuals, represent the total number of observations minus the number of independent variables in the regression model (df_regression) and the intercept term (if present). It measures the remaining degrees of freedom available to calculate the error or unexplained variability in the data.

Finally, the F value of 56.665 suggests that the regression model, which includes variation order complexity and final duration as independent variables, is highly significant in explaining the variance in cost overruns for construction projects. The model provides useful insights into how these variables affect cost overruns in the projects we studied and is not just due to chance or random fluctuations.

Table 4.3.2: Table of Coefficients

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0,1880	0,0744	-2,5283	0,0176	-0,3406	-0,0354
FINAL DURATION	0,0288	0,0031	9,1807	0,0000	0,0224	0,0352
COMPLEXITY OF VO	-0,0510	0,0355	-1,4361	0,1625	-0,1239	0,0219

Furthermore, through the regression model we can test the hypothesis. The first one is null hypothesis. This is used to express that there is no relationship between the two variables. The second one is the alternative hypothesis, which is used to express that there is a relationship between the variables taken in consideration, or to rephrase it, the independent variable has an impact on the dependent variable. Usually, the hypothesis is formulated as follows:

– H0: The independent variable has no impact on the dependent variable.
– Ha: The independent variable has an impact on the dependent variable.

Before engaging in further analysis and final assessment of hypotheses and the relationship between the variables one by one, we will first take a closer look at the regression equation based on the table of coefficients. The formula for the simple linear regression is Y= β + β X. In this case, the a is the intercept, the b is the coefficient related to the independent variable. X in this case, are all the values of the independent variables that we may consider seeing what might happen with the dependent variable.

$$Y = \beta0 + \beta1*X1 + \beta2*X2 + \dots$$

$$Y = -0.19 + 0.03 * X1 - 0.05 * X2$$

Y = – 0.19 + 0.03 * Final Duration – 0.05 * Complexity of VO

Now let us see one by one the most important value for each variable, which is the p value. Before that we will formulate the hypothesis, the null hypothesis, and the alternative hypothesis.

- H0: Final duration of the project has no impact on the overrun cost of the project.
- Ha: Final duration of the project impacts the overrun cost of the project.

To conclude on these hypotheses, we should delve into the p value of the final duration variable. According to the table of coefficients, the p value for this variable is almost zero. This signifies that p value is lower that alpha 0.05. The hypothesis that we will affirm will be the alternative one, which proves that there is a connection between the variables or to rephrase it, the final duration of the project impacts the overrun cost.

On the other hand, we have the complexity of the variation order. As it was mentioned above this variable is expressed through a scale of 1 to 5, each scale depending on different categories of changes on the project. The hypotheses related to this variable would be as follow:

- H0: The complexity of the variation order has no impact the overrun cost of the project.
- Ha: The complexity of the variation order does impact the overrun cost of the project.

According to the table of coefficients, the p value for this variable is 0.16. This value is larger than the value of the alpha value which is 0.05. Through this value we can conclude that the complexity of the variation orders does not impact the overrun of the project.

Another indicator that can express the validity of these hypotheses is the confidence interval. The confidence interval in the regression model is a limit of values that is bounded by two values, minimum and maximum. The essence of this interval is the fact that it expresses where the values of the model can fall. This interval, like the model itself, has a confidence level that can be 90 percent, 95 percent, or 99 percent. The confidence interval expresses at the same time the fact of how the data change but also the uncertainty related to the coefficients of the model. To conclude on confidence intervals in the same way as with p-values we declare that: we have a relationship between the variables taken into consideration if both values of the interval are located on the same side of the numerical axis. This can be both positive and negative. But if the confidence interval includes the value zero, it proves that there is no relationship between the variables. More specifically for our variables we have:

- **Final duration**: [0,0224; 0,0352] – both, the lower and upper limit of this interval are on the positive side of the numerical axis. This interval does not include 0 (zero). We can conclude the same as with the p value, that there is a connection between overrun cost and final duration of the project and the latter has an impact on the overrun cost.
- **Complexity of variation order**: [-0,1239: 0,0219] – as we can see, this interval is located on both sides of the numerical axis, meaning 0 (zero) is also part of this interval. Through this we can conclude on favor of the null hypothesis, that there is not connection between variables, complexity of Vos does not impact the overrun cost of the project.

On this section we will observe the coefficients of the regression statistics. Tables of regression statistics demonstrate the relationship between a dependent variable and one or more independent variables. This table is one of the outputs of the regression model and the most important coefficients are the R-squared and the adjusted R-squared. These values range from zero to 1. The closer their value is to 1, the more we can assert that the relationship between the dependent and independent variables is explained by the regression model. In other words, these coefficients express to what extent the model is able to explain the variation of the variables or how suitable this model is to analyze the variables.

Table 4.3.3: Regression Statistics table

Regression Statistics	
Multiple R	0,8987
R Square	0,8076
Adjusted R Square	0,7933
Standard Error	0,1657

Observations	30

Based on the table above, with a number of observations of 30, the following conclusions can be drawn:

- ✓ **The multiple R** is related to the strength and direction of the linear relationship of the variables. In our case, this coefficient is equal to 0.89, a value that presents of a positive, relatively strong correlation.
- ✓ **R square**: this coefficient expresses how much variability of the dependent variable can be explained by the independent variables that we have implicated in the model. From the value of the table, we can assert that the model is able to explain about 81 percent of the variability of the dependent variable. Considering that this value is close to 1, we can state that we have a satisfactory level of regression fit. To be more precise, in relation to our case, we can state that 81 percent of the variability of the project's cost difference is interpreted by the variable of duration until its completion.
- ✓ **The adjusted R square** adjusts the value of the coefficient above. This value is always lower as it explains that the model may also contain variables that are unable to contribute to the explanation of the variability of the dependent variable. In general, we can declare that the regression model is a good fit to study the relationship between the variables: duration, cost, and variability orders.

4.5 Simple Linear Regression

When undertaking a construction project, difficulties will always be present during its execution. This implies that projects may face variation orders. One of the factors that can affect the level of complexity of these orders is the size of the construction project. Basically, variation orders relate to changes that are made to the original project objectives. These orders can arise for various reasons such as technical, design. This sub-chapter will examine the relationship that exists between project size and the level of complexity of variation orders. To analyze the relationship between these variables, the simple linear regression method will be used.

To begin with, we will observe and analyze the results of the ANOVA table. One of the components of this table is the sum of squares. Basically, this component helps us to calculate the variability that exists in the data while also providing the evaluation of other factors. Specifically, in this study, we are concerned with the level of complexity of (project) changes or variation orders related to the project but explained by the other (independent) variable that is the project size. The p value is the value that conveys to us how valid this model is to study this relationship. As we have already mentioned, in order to have the desired result, this value must be smaller than alpha (in our case it is 0.05). By obtaining a p-value smaller than alpha, we can conclude that statistically, the relationship between the variables is significant. To put it succinctly, we will conclude that project size is a variable that affects the level of complexity of variation orders in a construction project.

Table 4.4.1: Anova Table for simple linear regression

	df	***SS***	***MS***	***F***	***Significance F***
Regression	1	18,93557392	18,93557392	32,59851082	4,0102E-06
Residual	28	16,26442608	0,58087236		
Total	29	35,2			

Conclusion of ANOVA: The p value of 4.0102E-06 is a very small value and this proves to us that there is a significant relationship between the variables. Below we will see and examine the results of the table of coefficients in detail.

Table 4.4.2: Coefficients Table

	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***
Intercept	2,097967	0,148865	14,093079	0,000000	1,793031	2,40290
PROJECT SIZE (m2)	0,000087	0,000015	5,709511	0,000004	0,000056	0,00012

If we were to formulate the relevant hypotheses for the variables of this model, we would have the following:

- **H0**: Project size does not affect the level of complexity of variation orders.
- **Ha**: Project size affects the level of complexity of variation orders.

Based on the table of coefficients, from the result of the regression model for the variables of project size and complexity of variation orders, we conclude as follows:

- ✓ **The intercept coefficient** of 2.097967 takes into account the value that the dependent variable would have if we assumed the dependent variable (project size) to be zero. Within the fundamental framework of the model, we would think that there is always a level of complexity created even under these conditions (a project with zero value).
- ✓ **The p-value**, which is related to the **intercept coefficient**, proves that the probability of the observations made, even if we reach the culminating point to think that there is no relationship between the variables, is very low. This value, which is less than our alpha value (0.05), indicates a level of significance for the model.
- ✓ **The coefficient related to the independent variable** (project size) has a value of 0.000087. According to the theoretical context, we would argue that for each unit of project growth, we would have an increase in the dependent variable (complexity) on average with the value of this coefficient extracted from the product of the model. Despite the model concluding that there is a relationship between the variables, this coefficient suggests a relatively small relationship.
- ✓ **The p-value of the independent variable** has a value of 0.000004. Even in this case, this value, compared to the value of alpha, suggests that statistically, there is an important relationship between the variables. To articulate it within the scope of this study's objectives, we can state that this value suggests that the size of the project affects the level of complexity of the variation orders.
- ✓ **The value of the T statistic** theoretically calculates the number of standard errors that the coefficient that is to be evaluated is far from the zero value. If this value is large, it suggests that we have sufficient evidence against the null hypothesis (which suggests that there is no relationship between the variables) and at the same time favors the alternative hypothesis. In the case of the cutoff coefficient, it is 14.093. This value is different from zero. This value

helps us to conclude that the explanatory coefficient contributes to explaining the complexity of variation orders in construction projects. The same thing happens with the t-value of the project size. This value is 5.709, which is significantly different from zero. This also conveys to the impact that project size has on variation orders during project execution. Thus, both of these values communicate a significant statistical relationship and a valid study model to conclude on the main hypotheses of the paper.

- ✓ **The confidence interval** theoretically offers us some values, or in other words a limit of values, within which we can assert with certainty (this certainty will also depend on the confidence level related to the applied model) that the parameters of our observations lie there or of the population. Based on the model output, the confidence interval for the project size coefficient ranges from 0.000056 to 0.00012. The lower bound tells us that there is a 95 percent probability that the true coefficient for the population is above the value. The opposite happens with the upper limit which exhibits us the maximum value. When the interval is not too wide then we have a greater probability that the estimates will be more accurate.

Table 4.4.3 Regression Statistics

Regression Statistics	
Multiple R	0,7334456
R Square	0,5379424
Adjusted R Square	0,5214404
Standard Error	0,7621498
Observations	30

- ✓ **The R-squared** coefficient theoretically explains the variability of the dependent variable. Based on the results of the model, this value is 0.5379 which asserts that approximately 54 percent of the variability of the variation order complexity variable is explained through this model.

- ✓ **<u>The adjusted value</u>** is 0.52144, which is more adjusted than the R-squared value considering the number of other variables or even the number of observations.
- ✓ **<u>The standard error</u>** calculates an average value for the variability of the complexity variable orders of variation, but which is not calculated by the regression model. Evidently, if this value is low, then we can declare that the model is suitable for studying the data we have.
- ✓ **<u>Conclusion</u>**: based on the above value and the fact that this model has considered only 30 observations, it can be inferred that additional factors may contribute on explaining the variability of the complexity of variation orders in construction projects.

4.6 Data Description: exploring key indicators

4.6.1 Mean, Median and Standard Deviation

Statistical analyzes include the examination of many indicators and their interpretation based on the circumstances and types of studies. The mean, median and standard deviation are essential indicators to describe and summarize a set of data. They provide important information as they talk about key trends and data distribution. Specifically, the mean provides a typical value and an overall representation of the data. This indicator can also be used when comparisons need to be made.

The median is a central value that divides a data set into two equal parts. The data is sorted from largest to smallest and the middle value is our score. This is also an important indicator, especially for the fact that it is resistant to extreme values. For this reason, it is a preferred indicator of central tendency. Usually, this indicator is used in cases where there is not an equal distribution of data. When the distribution of data is uneven or when a normal distribution cannot be assumed, the median is a more appropriate solution for representing central tendency.

Standard deviation is a statistical indicator that describes the distribution of data from the mean. Simply put, it is a value that indicates how far the data is from the mean. This indicator is calculated by taking the square root of the data variation. If we have a high value of the standard deviation, then the data is more widely distributed around the mean, while a small standard deviation indicates a narrower distribution. This indicator evaluates statistical certainty as it also reflects a level of representativeness of a sample for a given study.

4.6.2 Predicted and final cost

Based on the data provided for the 30 construction projects that we have as a sample of our study, the median, mean and standard error values were calculated. Calculations were performed using Excel formulas.

Estimated cost (expressed in millions of lek):

- ✓ Mean: the mean for the estimated cost for these 30 projects is ALL 178,270,307.89. This average results from the expected and projected costs of 30 construction projects. This value is so high because high-cost projects are also included in the sample taken in the study.
- ✓ Median: this statistical indicator for the estimated cost is 8,312,341.08 lek. The median refers to the central value of the estimated cost. Statistically, this is considered a good value to represent the average value of the projects. This value is not affected by projects that have very high costs. For this reason, the mean and median have a large difference.
- ✓ Standard deviation: for the estimated costs, this value is 664,728,425.6 lek. The result speaks of a very high variability of the estimated costs of the 30 projects. The bottom line is that projects have very different costs, causing a wide spread of estimated cost across all projects.

Final Cost (million lek):

- ✓ Mean: as for the final costs of the 30 construction projects, the average is 249,076,598.02 lek. Even in this case, the average is much higher than the median, reflecting the impact that high-cost projects have on the overall result.
- ✓ Median: the result of this indicator is ALL 10,715,192.00. The median talks about the central value of the final costs of the projects. Even in this case, it is considered a more reliable value than the average as it reduces the influence of the values of the larger projects that are part of the sample.
- ✓ Standard Deviation: this value in terms of the final cost is 1,016,152,018 lek. The high score reflects the high variability of final costs for construction projects.

Comparison between Estimated Cost and Completed Cost (million lek):

Average (mean):

- ✓ Estimated cost: 178,270,307.89 lek
- ✓ Completed Cost: 249,076,598.02 lek

The averages vary significantly, and the finished cost shows an average many times higher than the predicted one. This difference also speaks of the significant difference between the initial estimates and the final cost of the projects. These differences may also come from other factors such as delays, additional costs, unforeseen circumstances, variation orders, etc.

Median (median):

- ✓ Estimated cost: 8,312,341.08 lek
- ✓ Completed Cost: 10,715,192.00 lek

Standard Deviation:

- ✓ Estimated cost: 664,728,425.6 lek
- ✓ Completed Cost: 1.016.152.018 lek

In this case, the difference between these statistical values is quite visible. The result reflects a high variability between the two factors. The standard deviation also shows the same. So there is a wide variability between projected and final costs.

Inconclusion, we have very visible differences between the predicted and final values. These factors that were examined are important as it enables the assessment of the rate of change and helps to improve the process of forecasting and cost management of construction projects.

4.6.2 Predicted and final duration

The review of the statistical indicators of the average, median and standard deviation for the anticipated and final duration for the 30 construction projects are as follows:

Estimated duration (in months):

- ✓ Mean: the result for the average expected duration is 5.03333 months. This result is also influenced by projects that have a longer duration. Therefore, it makes the mean to be higher than the median.
- ✓ Median: the median for this variable is 3 months. The value of 3 months for construction projects is the central value of the estimated duration. This is not affected by the extended duration of some other projects.
- ✓ Standard Deviation: as for the expected durations, this indicator is 6.09400 months. This value also speaks for the high variability of the duration for the construction projects. So in other words, this tells us that there are significant differences between the estimated times for the projects.

Final Duration (in months):

- ✓ Average: the average for the duration for the 30 construction projects is 13.2333 months.
- ✓ Median: on the other hand, the median for the final duration for the 30 construction projects is 9 months. Again, the impact of projects with longer duration is reduced in this statistical indicator and therefore makes it a more reliable indicator of project duration.
- ✓ Standard Deviation: this value is 12.4698 months and speaks of the high variability showing a wide distribution of project duration.

Comparison between estimated and final duration:

Average (mean):

- ✓ Estimated duration: 5.03333 months
- ✓ Final duration: 13.2333 months

Median (median):

- ✓ Estimated duration: 3 months
- ✓ Final duration: 9 months

Standard Deviation:

- ✓ Estimated duration: 6.09400 months
- ✓ Final duration: 12.4698 months

All three indicators show big differences. Here we can understand how much projects have deviated from their original plans. This applies both to the costs that they had predicted and to the duration for the completion of the projects. For these reasons, very good forecasts and strategies are needed for the design and implementation of projects until their completion.

CHAPTER V

CONCLUSIONS

From the analysis of 30 construction projects through descriptive statistics and regression method, the following conclusions can be drawn:

1. Variability of project costs:
   a. Some projects demonstrated very small differences between the final costs and the projected costs for the completion of the project.
   b. Several other projects revealed significant cost overruns. This also helps us to reflect on the great challenges for accurately predicting total costs for a construction project.
   c. Due to the different issues or specific requirements of construction projects, it is very difficult to achieve a 100 percent accurate forecast of project costs.

2. Duration of projects:
   a. The graph reflects significant differences on construction projects and their final deadlines for completion.
   b. Most of the projects have exceeded the estimated deadline in significant numbers. Based on this, we can contend that these projects had a low level of efficiency and a poor performance of their implementation.
   c. A very small part of the projects has managed to be completed within the deadlines that were foreseen from the beginning.

3. Hypothesis 1: Project duration has an impact on construction project cost overruns:
   a. The p-value of the model was almost zero. Having this value proves that this variable has an impact on the cost of the project. So, we will accept what we have named as the alternative hypothesis of the regression model.

4. Hypothesis 2: The complexity of the variation orders affects the cost overruns of the construction project:
   a. The p value in this case was greater than the alpha value of 0.05. Based on this significant coefficient, we concluded that this variable has no impact on the project's cost overruns.
   b. This was confirmed by looking at the confidence interval in the model product, where the limits were found on both sides of the numerical axis, including in this case the zero value.

5. The regression statistics evidenced that in the case of the multiple regression model, the model was able to explain about 80 percent of the variability of project cost overruns vis-à-vis the independent variables.

6. Hypothesis 3: Project size affects the complexity of variation orders:
   a. The value of p tells us that the model is valid and expresses a statistically significant relationship between two variables.
   b. This is also proven through the confidence interval.
   c. However, further research is important to have a clearer framework of this relationship. This is confirmed by the coefficient of the regression coefficient which was able to explain only 53 percent of the variability of the complexity of the variation orders.

CHAPTER VI

RECOMMENDATIONS

The efficiency of a project is the most important part of it. In order for a project to achieve efficacy, it implies that it should be completed on time, managed to have maintained the required quality standard, was completed within the estimated costs or with very small differences, and there were as few changes as possible during its implementation. When variation orders are issued for a construction project, a good management of them should also be applied. Otherwise, it can result in significant overruns both in terms of duration and total costs. Listed below are some recommendations on how to properly manage these orders.

1. **Clear definition of the purpose and objectives of the project:**
   a. The purpose of the project should be well defined and also very explicit.
   b. It is important to document everything, starting with the main goal of the project.

2. **Ensuring clear communication and effective cooperation between all parties involved in the project:**
   a. It must be ensured that all parties involved communicate openly with each other and this communication is effective.
   b. Periodic meetings should be organized to discuss the progress of the project and the solution of the problems they may currently be facing.
   c. Different software can be applied for project management, to be able to monitor from every aspect but also to simplify the communication between the parties.

3. **Effective scheduling of projects and the culminating points of each of its phases:**
   a. A very detailed plan should be compiled with dates and timelines for each phase and each meeting when they will need to discuss the following next steps.
   b. The duration should be planned by thoroughly documenting and recording each phase of the project, including the initial procurement phase.

4. **Accurate cost analysis:**
    a. Starting from the purpose of the project, from the necessary materials, from the technical side and other details, the costs must be calculated as accurately as possible without overlooking any point.
    b. These costs should be regularly updated and monitored to see in detail how they exceeded or met their specific objective.

5. **Early identification of variation orders that may be necessary to be applied to the project:**
    a. From the beginning of the project, a strategy must be drawn up about the approach that will be followed to manage the necessary changes during implementation.
    b. All parties must be included in this strategy without any exception.

6. **Continuous documentation control:**
    a. A centralized documentation management system should be created that will reflect each step of the project including changes at each stage.
    b. Documentation for variation orders should be updated regularly and periodically.

7. **Effective risk management:**
    a. Risks related to costs, project size and costs needed to completion must be identified and assessed.
    b. Creation of strategies and techniques that will help in effective risk management throughout the life of the project.

BIBLIOGRAPHY

Arain, F. M., & Low, S. P. (2005). The Nature and Frequency of Occurence of Variation Orders for Educational Building Projects in Singapore. *International Journal of Construction Management*, 79-91.

Bower, D. (2000). A systematic approach to the evaluation of indirect costs of contract variations. *Construction Management and Economics* , 263-268.

Dosumu, O. S., & Adenuga, O. A. (2013). Assessment of Cost Variation in Solid and Hollow Floor Construction in Lagos State . *Journal of Design and Built Environment* .

Fisk, E. R. (1997). *Construction Project Administration.* New York: Wiley.

Hanna, A. S., Camlic, R., Peterson, P. A., & Nordheim, E. V. (2002). Quantitative Definition of Projects Impacted by Change Orders. *Journal of Construction Engineering and Management*, 57-64.

Ibbs, C. W., Wong, C. K., & Kwak, Y. H. (2001). Project change management system. *Journal of Management in Engineering*, 159-165.

Kikwasi, G. (2012). Causes and Effects of Delays and Disruptions in Construction Projects in Tanzania . *Australasian Journal of Construction Economics and Building-Conference Series*.

Love, P. E., Liu, J., Regan, M., Smith, J., & Irani, Z. (2017). Cost performance of public infrastructure projects: the nemesis and nirvana of change-orders. *Production Planning & Control* .

Memon, A. H., Rahman, I. A., & Hasan, M. F. (2014). Significant Causes and Effects of Variation Orders in Construction Projects. *Journal of Applied Sciences, Engineering and Technology*, 4494-4502.

Mendelssohn, I. A., Hester, M. W., Monteferrante, F. J., & Talbot, F. (1991). Experimental Dune Building and Vegetative Stabilization in a Sand-Deficient Barrier Island Setting on the Louisiana Coast, USA. *Coastal Education & Research Foundation, Inc.* , 137-149.

Mohamed, A. A. (2001). *Analysis and management of change orders for combined sewer overflow *construction projects.* Wayne State University ProQuest Dissertations Publishing.

Ndihokubwayo, R. (2008). An analysis of the impact of variation orders on project performance. *Cape Peninsula University of Technology, Theses & Dissertations*.

O'Brien, J. J. (1998). *Construction Change Orders: Impact, Avoidance, Documentation.* New York: McGraw Hil.

Saukkoriipi, L., & Josephson, P. (n.d.). Non-Value Adding costs in the Public Sector: The Influence on Costs for Construction Projects. *Working paper*.

Seyar, A. (2020, May 6). *How to Manage Change Orders in Your Construction Project* . Retrieved from Linkedin.

Ssegawa, J., Mfolwe, K., Makuke, B., & Kutua, B. (2002). Construction variations: a scourge or a necessity. *International Conference of CIB W107*, (pp. 11-13).

Sunday, O. A. (2010). Impact of Variation Order on public construction projects. *26th Annual ARCOM Conference* (pp. 101-110). Leeds: Association of Researchers in Construction Management.

Thomas, H. R., & Napolitan, C. L. (1995). Quantitative Effects of Construction Changes on Labor Productivity . *Journal of construction engineering*, 290-296.

APPENDIX 1

PREDICTED OVERALL COST	FINAL OVERALL COST	OVERRUN COST	OVERRUN COST (bln)
20.910.273,00	21.733.709,00	823.436,00	0,00082
47.984.121,00	52.975.820,00	4.991.699,00	0,00499
8.022.288,00	8.837.508,00	815.220,00	0,00082
29.031.146,00	31.131.146,00	2.100.000,00	0,00210
20.157.827,36	22.788.685,76	2.630.858,40	0,00263
6.087.139,78	9.121.733,78	3.034.594,00	0,00303
12.788.268,17	13.588.268,17	800.000,00	0,00080
8.411.127,15	8.411.127,15	0,00	0,00000
5.948.930,16	6.648.826,74	699.896,58	0,00070
247.000.000,00	247.200.000,00	200.000,00	0,00020
3.500.000.000,00	5.500.000.000,00	2.000.000.000,00	2,00000
8.559.787,00	10.359.787,00	1.800.000,00	0,00180
4.718.138,00	5.018.138,00	300.000,00	0,00030
1.613.089,00	1.738.089,00	125.000,00	0,00013
9.616.449,00	23.044.449,00	13.428.000,00	0,01343
11.115.340,00	12.465.340,00	1.350.000,00	0,00135
6.529.279,00	6.659.279,00	130.000,00	0,00013
8.213.555,00	9.913.555,00	1.700.000,00	0,00170
7.770.597,00	11.070.597,00	3.300.000,00	0,00330
9.616.449,00	11.176.449,00	1.560.000,00	0,00156
3.829.606,00	7.829.606,00	4.000.000,00	0,00400
1.613.089,00	3.613.089,00	2.000.000,00	0,00200
2.176.952,00	3.676.952,00	1.500.000,00	0,00150
3.430.405,00	4.230.405,00	800.000,00	0,00080
1.199.479.928,00	1.209.479.928,00	10.000.000,00	0,01000
2.100.816,00	3.700.816,00	1.600.000,00	0,00160
2.605.284,00	3.605.284,00	1.000.000,00	0,00100
99.479.928,00	144.479.928,00	45.000.000,00	0,04500
52.714.789,00	62.714.789,00	10.000.000,00	0,01000
6.584.636,00	15.084.636,00	8.500.000,00	0,00850

PREDICTED DURATION	FINAL DURATION	COMPLEXITY VO	PROJECT SIZE (m2)
6	18	2	1540
6	18	4	12000
6	18	2	360
6	18	3	2500
5	18	3	1536
3	18	2	417
3	18	2	916
3	18	2	711
6	14	2	234
6	24	5	43200
36	72	5	28000
6	6	3	585
2	6	1	298
1	2	1	90
2	6	3	548
2	6	2	132
2	6	1	97
2	6	2	117
3	8	2	342
3	8	2	240
3	8	2	144
3	7	2	120
3	7	2	117
3	6	2	78
6	10	4	3600
3	7	1	67
3	6	1	73
6	14	4	3600
6	12	3	1548
6	12	2	450

APPENDIX 2

Predicted Overall cost (mln lek)	
Mean	178.270.307,89
Median	8.312.341,08
Standard Deviation	664.728.425,63

Final Overall cost (mln lek)	
Mean	249.076.598,02
Median	10.715.192,00
Standard Deviation	1.016.152.018,48

Predicted Duration (in months)	
Mean	5,03333
Median	3
Standard Deviation	6,09400

Final Duration (in months)	
Mean	13,2333
Median	9
Standard Deviation	12,4698