

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE
ENGINEERING and TECHNOLOGY

**AN INVESTIGATION INTO COST VARIATIONS IN FIT-OUT
CONSTRUCTION PROJECTS**



M.Sc. THESIS

Gizem ÇALIŞ

Department of Architecture

Project and Construction Management Programme

NOVEMBER 2018

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**FIT-OUT İNŞAAT PROJELERİNDE BÜTÇE VARYASYONLARI ÜZERİNE
BİR İNCELEME**

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To my mother and father,



FOREWORD

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ABBREVIATIONS

HVAC	: Heating, Ventilating and Air Conditioning
FF&E	:Furniture, Fixtures and Equipments
EMEA	: Europe, the Middle East and Africa
EC	:Estimated Cost
AC	:Actual Cost
VC	:Variation Cost
CoC	:Change Order Cost
VP	:Percentage of Variation
CoP	:Percentage of Change Order



SYMBOLS





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AN INVESTIGATION INTO COST VARIATIONS IN FIT-OUT CONSTRUCTION PROJECTS

SUMMARY

Construction projects are always complicated and complex by the reason that they are a combination of technical subjects based on science and management subjects based on humanities. The existence of many participants and various factors composes the complex and inconsistent network. Lifestyle and demands of the end-users' expose the construction projects to changes during the execution phase.

The factors for evaluation of the success of the project are various; however, the completion of the project in the expected budget is an important criteria for all of the project participants. As for the achievement of the success of the project in terms of cost, are related to accuracy of the estimated cost prepared by design and tender documents and other factors that affecting the cost. The estimated cost which are affected by these factors become actual factors at the closing phase. The differences between the estimated cost and the actual cost are defined as cost variations. Awareness about the importance of the cost variations and determining the causes of the cost variations are considerably important to accept the project is successful. These causes are listed various times among the different possibilities and determined project groups by researchers. On the other hand, the studies over the "fit-out" projects that are spread out by the popularity of the lately life styles are fewer.

As the prevalence of the fit-out projects are enhanced, the researches in this area become important. Completion and commissioning of the shell and the structure of the specific building is called "shell and core", completion and operation of the rest of each separated part by their users' is called "fit-out" projects. Therefore, the extent of the fit-out projects are narrower due to the similarity of the work items. Nevertheless, cost variations in fit-out project are seen widespread.

Determination of the cost variations in which areas and in which work items are important to make provision for these areas and to mitigate the cost variations. Determination of the most effective work items in cost for the fit-out projects and to take cognizance of these work items may be a solution for the mitigation of the cost variations.

Presented research remarks the causes of the cost variations and their consequences. The main aim of this research is to identify the significant work items having cost variations in the fit-out projects. Number of methods are used to gather the data while the work items are identified. As a result of the searches by the previous studies are used to determine the causes of the cost variations. These causes are investigated under four categories following: changes during the construction process, contractual issues, the efficiency of the project management and the accuracy of the estimated cost. After

the literature investigation, 10 fit-out projects of a company are used as case studies to list the most effective work items on cost. The results of the case studies are discussed with the authorized persons in the projects to establish the causes of the detected cost variations. The authorized persons who was choosen are selected from different departmans to include the different perspectives. The relations between all data obtained are discussed to achieve the conclusion.

Gathered cost variation factors from literature survey, quantitative data from case studies and causes of the cast variatons in the case studies are explained in the conclusion section in detail. The results are summurazied under two subtitle: the most effective work items on cost variations and common causes of cost variations in fit-out projects. 8 work items are listed when the mean of 80% of actual costs are calculated, these work items are Finishes, Furnitures, Openings, Metals, Existing Conditions, Electrical works and Concrete works based on the impact on actual cost. The mean percentage of the accured cost work items are 35,20% for Finishings, 22,63% for Furnitures, 15,32 for Openings. The mean cost variation and change order values are established through 80% of actual costs. The information gathered from the inteivews summarize that the common causes are change orders, delay in decision of the owner, unefficiencies during the design and construction and communication problems.

The results obtained from this research contains data both for the owners and the contractors to reduce the variations. The contractor can estimate the contingencies and their costs by using the mean of the change orders for the work items during the tender process. The precautions can be set during the execution phase to avoid the mostly occurred changes and factors affecting the cost.

Contractors and owners can discuss about the remarkable subjects for the contract and negotiate for changes in contract to reduce the change orders and cost variations. Owners can determine on their budget by the prescience of the variations while they decide the bidding price of contractors. Owners can have information for the important points of the project delivery systems and payment methods.

Consequently, the impact of the detected work items and the factors affecting the cost variations on these work items by the regard of this research have an important part on the success of the projects. The consideration of these results during the planning will get closer the projects to the success more.

FIT-OUT İNŞAAT PROJELERİNDE BÜTÇE VARYASYONLARI ÜZERİNE BİR İNCELEME

ÖZET

İnşaat projeleri bilime dayalı teknik konular ve insani ilişkilere dayalı yönetsel konuların bir kombinasyonu olduđu için her zaman karışık yapılar ve ilişkiler içermektedir. İnşaat projelerine dahil olan birçok paydaşın ve tasarım ve plalamayı etkileyen faktörlerin varlığı ise bu karmaşık yapıyı ve ilişkiler ağıının değışkenliğine neden olmaktadır. Son kullanıcıların yaşam şekilleri ve talepleri yapım sırasında inşaat projelerinin değışikliğe uğramasına neden olmaktadır.

İnşaat projelerinin başarısını belirlemedeki faktörler ise çeşitlidir ancak projenin öngörülen bütçe içerisinde tamamlanması ise tüm proje tarafları için önemli bir kriterdir. Projenin bütçe konusunda başarıya ulaşması ise projenin başında tasarım ve ihale dokümanlarına göre hazırlanan tahmini maliyetinin doğruluk derecesi ve proje süresince tahmini maliyeti etkileyen diğer faktörlere bağlıdır. Bu faktörlerden etkilenen tahmini maliyet projenin kapanış aşamasında sonuçlanan gerçek maliyete dönüşür. Proje sürecince oluşan tahmini maliyet ve gerçek maliyet arasındaki farklar maliyet sapmaları olarak tanımlanmıştır. Maliyet sapmalarının önemi konusundaki farkındalık ve bu sapmaların sebeplerinin belirlenmesi projenin başarılı sayılması için oldukça önemlidir. Bu sebepler çeşitli olasılıklar ve belirlenmiş proje grupları arasında araştırmacılar tarafından defalarca listelenmiştir. Ancak, son yılların yaşam kültürü ile popüler olarak yaygınlaşmış bir proje tipi olan “fit-out” projeler üzerinde yapılan çalışmalar daha azdır.

Fit-out projelerin yaygınlığı arttıkça bu alanda yapılan çalışmalar da önem kazanmaktadır. Belirli bir binanın kabuk ve strüktürünün tamamlanarak ortak alanlarının devreye alınmasına “shell and core”, bu alanlar dışındaki her ayrılmış bölümün kendi kullanıcıları tarafından tamamlanarak kullanıma alınmasına da “fit-out” denilir. Binanın yapım sürevi bu nedenle iki ayrı faz olarak düşünülebilir. Birinci fazda ana yüklenici tarafından bina dışarıdan bitmiş olarak görünecek şekilde, ortak alanlar da tamamlanmış şekilde yatırımcı yada mal sahibi yada işletmeciye teslim edilir ve yalnızca altyapı bağlantıları bırakılmış her farklı özel alan farklı müşterilere kiralanır yada satılır. Bu özel alanların kiracıları yada mal sahipleri kendi belirleyecekleri tasarımcı ve yüklenicileri ile bina teknik şartnameleri ve yönetmeliklere uygun olacak şekilde kendi alanlarını tamamlar. Bu durumda ikinci faz olarak adlandırılan süreçte her özelleşmiş alanda farklı tasarımcılar ve yükleniciler ile birlikte birden çok fit-out projesi devam eder. Her biri birbirinden bağımsız olan bu projeler yine farklı ekipler tarafından yürütülür. Fit-out projelerde yaygın olarak benzer olan işler; elektrik ve mekanik altyapıların bina sisteminden beslenerek tasarıma göre tamamlanması, aydınlatma işleri, bitiş kaplamaları, özel üretim ve hareketli mobilyalar, kullanıcının kurumsal yada tasarım kimliğini ortaya koyan logo ve reklam işleridir. Fit-out projelerin kapsamı iş kalemlerinin birbirlerine benzerliği nedeniyle diğer projeler göre daha dardır. Buna rağmen, fit-out projelerde de maliyet sapmaları yaygın görülen bir olgudur.

Sapmaların en çok hangi alanlarda ve hangi iş kalemlerinde meydana geldiğini belirlenmesi bu konularda önlemler alınması ve fit-out projelerinde oluşan sapmaların azaltılması için önemlidir. Fit-out projelerini oluşturan iş kalemlerinden maliyete en çok etkileyenlerin belirlenmesi ve bu iş kalemlerine tahmini maliyet analizlerinde daha çok önem verilmesi bu maliyet varyasyonlarının azaltırması için bir çözüm oluşturabilir.

Sunulmakta olan bu çalışma ile maliyet sapmalarını oluşturan sebepler ve maliyet sapmalarının sonuçlarına dikkat çekilmektedir. Bu çalışmanın ana amacı fit-out projelerinde sapmalara neden olan iş kalemlerinin belirlenmesidir. Bu iş kalemleri belirlenirken birden fazla yöntem ile veriler elde edilmiştir. Daha önceki yapılan çalışmaların araştırmalarından maliyet sapmalarının sebepleri belirlenlenmeye çalışılmıştır. Bu sebepler tahmini bütçenin doğruluk derecesi, inşaat sırasında gerçekleşen değişiklikler, sözleşmesel konular ve proje yönetiminin yetkinliği olarak dört grupta incelenmiştir. Literatür incelemesinin ardından bir firmanın tamamlanmış olan 10 adet projesi üzerinden maliyeti etkileyen en önemli iş kalemlerini tespit edebilmek için alan araştırması kullanılmıştır. Bu alan araştırmalarının sonuçları verilerin alındığı firmanın proje yetkilileri ile görüşülerek bu değişikliklere sebep olan faktörler tespit edilmiştir. Görüşülen firma yetkilileri farklı görüşlerin tespit edilebilmesi için farklı departmanlarda çalışan kişilerden seçilmiştir. Tüm elde edilen verilerin birbiri ile ilişkileri tartışılarak sonuca ulaşılmıştır.

Alan araştırmasında kullanılan sayısal veriler fit-out projelerinde uzmanlaşmış bir firmadan alınmıştır. Projeler geleneksel proje teslimi ve tasarım yapım proje teslim sistemi olmak üzere 2 farklı proje teslim sisteminden biri ile tamamlanmıştır. Firma, projelerde ana yüklenici yada tasarımcı ve ana yüklenici rollerinde bulunmuştur. Alınan veriler; firmanın şirket genel gider ve karı alınmadan projede yer alan işlerin tahmini maliyetleri ve gerçekleşen maliyetleridir.

Literatür çalışmasından elde edilen maliyet sapmalarını etkileyen faktörler, alan araştırmasından elde edilen sayısal veriler ve mülakatlardan alınan örnek projelerin sapma nedenleri arasındaki ilişkiler sonuç bölümünde detaylı olarak açıklanmıştır. Bu sonuçlar şu iki önemli başlık altında özetlenmiştir: Fit-out projelerinde maliyet sapmalarına en çok neden olan iş kalemleri ve fit-out projelerinde maliyet sapmalarını oluşturan genel sebepler. Gerçek maliyetin %80'ini oluşturan iş kalemlerinin ortalaması alındığında 8 adet iş kalemi listelenmiştir. Bu iş kalemleri gerçek maliyeti etkileme yüzdesine göre; bitiş kaplamaları, mobilyalar, doğrama ve kapılar, metal işleri, mevcut koşullar, elektrik işleri, beton işleri ve ekipmanlardır. Bu iş kalemlerinden 10 projede gerçekleşme yüzlerine göre ortalama olarak bitiş kaplamaları projelerin %35,20'sini, mobilyalar projenin %22,63'ünü ve doğrama ve kapılar projenin %15,32'sini oluşturmaktadır. Projelerin gerçek bütçesinin %80'inin oluşturan iş kalemlerinin ortalama maliyet sapması yüzdeleri ve ortalama değişiklik emiri yüzdeleri tespit edilmiştir. Yapılan mülakatlardan elde edilen verilere göre, değişiklik emirleri, işverenin karar vermedeki gecikmeleri, tasarım ve inşaat sırasındaki yetersizlikler ve iletişim sorunları genel sebepler olarak özetlenmiştir.

Bu çalışmanın sonucunda elde edilen veriler hem yüklenici hemde işveren için maliyet sapmalarının azaltılması için sonuçlar içermektedir. Yüklenici firmalar için ihaleye girerken risk marjlarının belirlenmesi için iş kalemlerinde oluşan maliyet sapmalarının ve değişiklik emirlerinin belirlenen ortalama yüzdeleri dikkate alınarak tahmini bütçeleri oluşturulabilir. İnşaat sırasında sıklıkla meydana gelen değişiklikler ve maliyeti etkileyen faktörler için projenin inşaatı sırasında maliyet sapmalarını

önlemeye yönelik önlemler alınabilir. Yüklenici ve işveren arasında yapılan anlaşmalarda dikkat edilmesi gereken konular belirlenebilir ve değişiklik emirlerini ve maliyet sapmalarının önüne geçilmesi için bazı değişiklikler üzerinde anlaşılabilir. İşverenler, inşaat sonunda gerçekleşen maliyetin tahmini maliyetten ne kadar sapacağı öngörüsü ile seçilecek yüklenicinin teklif tutarını belirleyebilirler. İşverenler proje teslim sistemi ve ödeme yöntemlerini belirlerken dikkat edilmesi gereken konular hakkında fikir edinebilirler.

Sonuç olarak; bu çalışma ile belirlenen iş kalemlerinin etki dereceleri ile bu iş kalemlerindeki sapmalara neden olan faktörler projenin başarıya ulaşmasında önemli rol oynamaktadır. Bu sonuçların dikkate alınarak gelecek projelerin planlamasının yapılması gelecek projeleri bir adım daha başarıya yaklaştıracaktır.





1. INTRODUCTION

1.1 Background of the Problem

Complex and inconsistent nature of the construction projects are the most mentioned characteristics in project management practices. Therefore there are researches show that all control mechanisms and management techniques in other sectors are not easily applicable and working enough in the construction sector. The existence of many participants, involve in the process, and various factors, affecting the design and planning, composes the complex and inconsistent network. Construction projects that directly affect end-users' life after the construction phase are exposed to changes by lifestyle and demands of the users'.

The conditions in the initial work scope and the needs of the project may change, no matter how accurate the planning is. Keane et al. (2010) stated: *“The need to make changes in a construction project is a matter of practical reality.”* A well-prepared contract has special conditions for the possible changes in the project. Any participant may cause the changes during the construction. Although the changes are expected, not all changes are predictable. To meet the changes and control the cost are difficult but also important. The possible impact of the changes and effects on time, cost, quality etc needs to be considered to avoid unwelcomed consequences.

Changes usually result in the extent or retract of the work scope in the contract which is a matter of cost. It is found out that financial issues have the highest impact on disputes (Sertyesilisik, 2010). Therefore cost effects of the changes are paid more attention. Cost variations are analyzed through the difference between the estimated and actual cost in an effortless but systematic way (Lim et al., 2016). Detailed comparisons between estimated cost and actual cost are suggested by an efficient cost control system for accurate accounting (CSI, 2005). To meet these changes in actual cost and to make a profit, estimators insert additional costs into their budget. This tendency affects the estimated cost to increase certainly and it may cause to lose the competition of getting the project in the current market conditions. Contractors prepare cost estimations competitively low to win the bid however high enough to have profit

(Kim et al., 2008). The accuracy of the contingency and the estimated cost is important for both to get the job and to avoid cost variations in actual cost. The challenge here is how to lower these variations and state how much and where the companies lose their contingencies.

The accuracy of the cost estimation is important for the success in the construction project management and for the client satisfaction. All stakeholders of a project give importance to the reliable and accurate cost estimates (Lim et al., 2016). Cost overruns, however, are frequently encountered in the considered projects (Touran, 2003b). Various factors affect the accuracy of the estimated cost. Complicated connections among the participants and nonhuman factors such as long duration, ambiguity in conditions form construction contracts complex (Keane et al., 2010). Additionally, because of good communication between participants can result in early termination than expected schedule and the decreasing of the project duration can decrease general expenses such as mobilization. Other factors can be; economic conditions of the sector or country, the special conditions of the project, direct or indirect people who involved the project and management system or capability of the project. As Cantarelli et al. (2012) found out that Netherlands have more cost overruns in transportation infrastructure projects than other countries depending on geography. For instance, if the location of the project is difficult to reach and presence of the planning is not prepared based on this specialty, every transportation expenses may result in more than previous studies.

Cost control and cost estimation methods are argued research subject in the project management areas. Due to the effect on the cost, the reasons for the changes have been searched in detail. Several estimation and risk management systems are suggested. Several studies investigated the contingency allocation and proposed models for it (Touran, 2003b). Cantarelli et al. (2012) investigated the effects of project type, implementation phase and size on cost. Lim et al. investigated the various factor affecting the cost of the project based on types of works in residential buildings by comparing two case study. In spite of the previous researches, the deficiency on the cost control is still a subject.

The project management area is wide and the differences between the projects are uncountable, the current tendency in the sector is to get specialized in specific work areas. Specialization of contractors helps them to control the budget easier. As a result

of this special expertise, the buildings are tendered in the phases such as shell and core and fit-works. Shell and core or base build are constructed structural elements of a building or space, even the building is looked completed from outside while the interiors are uncompleted. Fit-out works are both completed installations such as mechanical, electrical and plumbing services, as well as finishings and design specifications of the tenants (Oktra, 2018). The lifestyles and the new expectations of people change the accustomed living spaces. The seeking of adapting the trends and decreasing the costs of the companies lead the rental practices to change. Although fit-out construction becomes widespread, there are fewer researches directly focused on fit-out constructions. The case studies in this research are selected from fit-out construction projects with the expectation of getting accurate results in a specified scope of work.

1.2 Research Aim and Objectives

This research aims to identify the significant work items having cost variations in the fit-out projects. Work item based cost system is selected to define the variations on fit-out projects. Variations described as; the differences between actual cost and estimated cost. Therefore; the changes are detected between the actual cost and estimated cost based on work items in the case studies. This research has six main objectives: (1)to determine the causes of cost variations based on change orders, (2)to determine the causes of cost variations based on contract and project management, (3)to analyse factors affecting the accuracy of the cost estimation, (4)to analyse the cost estimation methods, (5)to identify the most effective work items in variations in fit out projects, (6)to establish the most significant factors leading the variations in fit-out projects (Table 1.1).

This study focuses on the fit-out projects and their specialized work items through similar projects by their scope. For instance, earthworks, roofing or facade works are not included in the analysis due to the nature of fit-out projects. The range of the project types includes office, restaurant or housing. The mutual point of each project is designed for corporative clients in an environment that only structural elements are finished. On the other hand, each project has its special conditions, while one of the projects include a lift construction, the rest of the projects do not include in their scope. To achieve aimed objectives above, a wide literature review has been carried out. The

variations of 10 fit-out projects were questioned by the significance of the factors mentioned in the literature review.

Table 1.1 : Research aim and objectives.

Aim	Objectives	Research methods
To identify the significant work items having cost variations in the fit-out projects	To determine the causes of cost variations based on change orders	Literature Review
	To detect the causes of cost variations based on contract and project management	Literature Review
	To analyse factors affecting the accuracy of the cost estimation	Literature Review
	To analyse the cost estimation methods	Literature Review
	To identify the most effective work items in variations in fit out projects	Case Study
	To establish the most significant factors leading the variations in fit-out projects	Interview based on Case Study

1.3 The content of the Study and Methodology

Chapter 1 draws the concept and objectives of the research. The research terminology has been defined and their relationship with the process has been clarified. The main aim of the research has been introduced to identify the significant work items having cost variations in the fit-out projects. The scopes of the projects are defined as fit-out project in the research. The remaining Chapters will investigate the causes and the effects of variations, data gathered by case studies and the conclusions drawn from the research.

In Chapter 2, the research continues with the overview of cost variations. In this Chapter, the importance of the cost variations and the causes behind it are the

predominantly discussing point. Additionally, estimation techniques and factors affecting the cost estimation are defined. As a result of literature reviewing, factors affecting cost variations and effects of the variations are listed.

Chapter 3 reviews each project and their significant events, and explains the method used in order to data collective and organization. Identification of the work items based on Master Format is explained. The main subjects of the interview questions and the background of the interviewees are expressed for the further steps of the research.

In Chapter 4 the work items are examined by their cost variation and change order impact on the actual cost. The 10 projects categorized according to work items and sorted by their costs. The cost variations and change orders are analyzed by their magnitude in the level of the work item and in the level of total project in order to compare each work item. The responses of the interview questions are detailed by the aspect of interviewees. In addition; the causes and results of the case studies and interview are discussed with the literature. The similarities and poor connections are stated for readers.

Chapter 5 is the conclusion part that findings and conclusions are presented. The usage areas of the research are explained. Areas of further researches are also suggested in this Chapter.

As methodology: a literature review has been done on books and researches, in consequence, accepted causes and effects and estimation techniques on cost-related issues of different approaches represented in this research. The Master Format 2016 used in case studies to identify the work items and Pareto principle has been applied as a criteria to elect significant work items in Chapter 3.

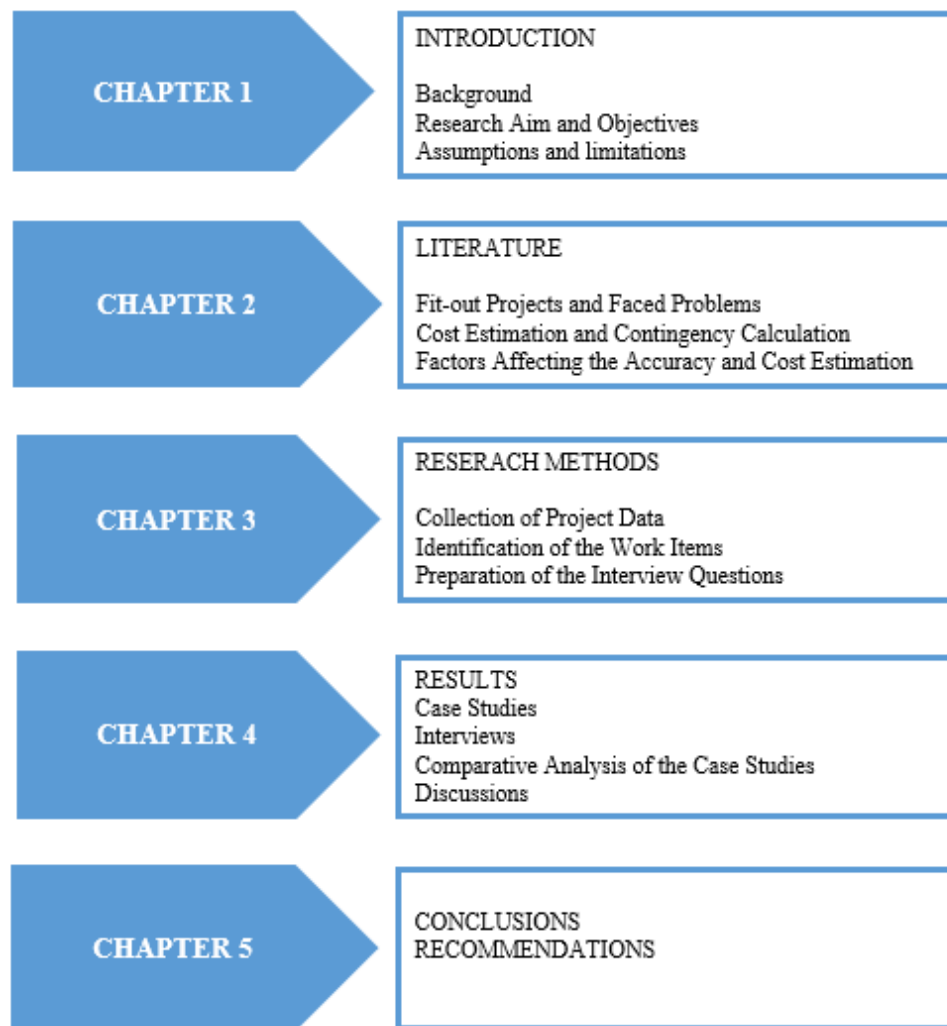


Figure 1.1 : The flow chart of the research content

2. COST VARIATIONS

Every project starts with the aim and objectives and follows them to finalize the project successfully. Success is defined as *“the favorable or prosperous termination of attempts or endeavors; the accomplishment of one's goals”* in Thesaurus. (URL-2, 2018). In construction projects, the goal is to complete the construction in scheduled time and estimated budget. Although the predictions and planning are considered useful enough, conditions change in execution phases in construction. In addition, the clear scope of works are not guaranteed the coordination or the communication between designer and contractor and owner's requirement and commands can change in time.

Any type of project has variations hence the changes in cost are noticed and controlled carefully. The divergence of designed scope or schedule of works by the architect, contract administrator or the employer results in variations (Chappell, 2011). Experienced project managers are aware of the changes in the process. Furthermore, successful management is the ability to control unforeseen changes.

Variations can occur in different areas. Various research is focused on the effects of variations as success criteria through cost, time, quality, performance and health, and safety issues. One of the most important factors of success is accepted as cost in any project (Bhawsar et al., 2016). By the reason of the importance of cost for any stakeholder; cost overruns are monitored and analysed carefully.

Factors of affecting variations occur either in the preliminary stages or in the execution stages. Cost overrun is defined as the percentage of estimated costs and it is calculated by decreasing the estimated costs from actual out-turn costs, which is calculated and occurred at the final of the project (Cantarelli et al., 2012). Cost variations can be caused by several reasons and in every phase of a project, therefore, these variables between actual cost and estimated cost are investigated. Construction-specific factors and economic and political-specific factors are uncontrollable but occur during the construction and increase the difference between the actual cost and

the estimated cost of a project (Sinesilassie et al., 2017). Akinci and Fischer draw a knowledge map illustrating factors affecting the quantity and unit cost of both the estimated cost and the final cost (Akinci and Fischer, 2003). While some of the cost variation factors affecting only estimated cost, others are related to actual cost at the final of the project. Tran et al. (2018) searched for the projects with guaranteed maximum price contracts in every phase besides presented that estimation method, contingencies and change orders have effects on the implications between actual cost and estimated cost.

Estimation of the initial budget is an important component in the equation. Therefore, an appropriate method of estimation should be determined for the project specialties. Numerous methods are conducted in different phases of a project by different researchers such as; common elaborated and simplified breakdown methods, methods based on work types, cost functions, and other expert and hybrid systems (Arafa and Alqedra, 2011). In addition to the appropriate estimation method, the accurate estimate is a matter of success. Estimation is a complex process besides an accuracy of estimation is an indication of the success or the failure project (Hatamleh et al., 2018). Cost estimation is set up on design specialties, contractual clauses and external impacts (Lim et al., 2016) (Jahren and Ashe, 1990). To have a better estimation all of the parameters should be examined by the experienced estimator (Elfaki et al., 2014) (Serpell, 2004).

All changes in every phase of the project need to be questioned for a better understanding of the variations. Although delay and cost overrun can be seen in any phase of the construction, cost overruns mostly occur because of the factors in execution phase (Frimpong et al., 2002). Starting from preliminary stages until end of execution phase, the cost is calculated routinely. The estimated budget needs to be revised according to the needs of the up to date project (Sinesilassie et al., 2017). New requirements are documented during the construction phase. The documents in order to apply the changes to the contract scope are change orders (Keane et al., 2010). Furthermore, renewing the action plan is a continuing process until the end of the project. Risk and uncertainty have an inverse ratio with the cost of changes during the lifecycle of a project (PMI, 2013). Awareness of the possible factors during this process makes easier to have a position against variations. Flyvbjerg et al. state that cost underestimation is a result of cost escalation and there is no improvement to get

better due to tactically to get projects approved and built (Flyvbjerg et al., 2003). Despite Flyvbjerg et al's allegation, consequences of the variations should be examined carefully in order to understand its importance. The purpose of the cost monitoring is comparing the cost of the changes and remaining budget sources. The crucial point of construction cost monitoring is to be aware of the causes.

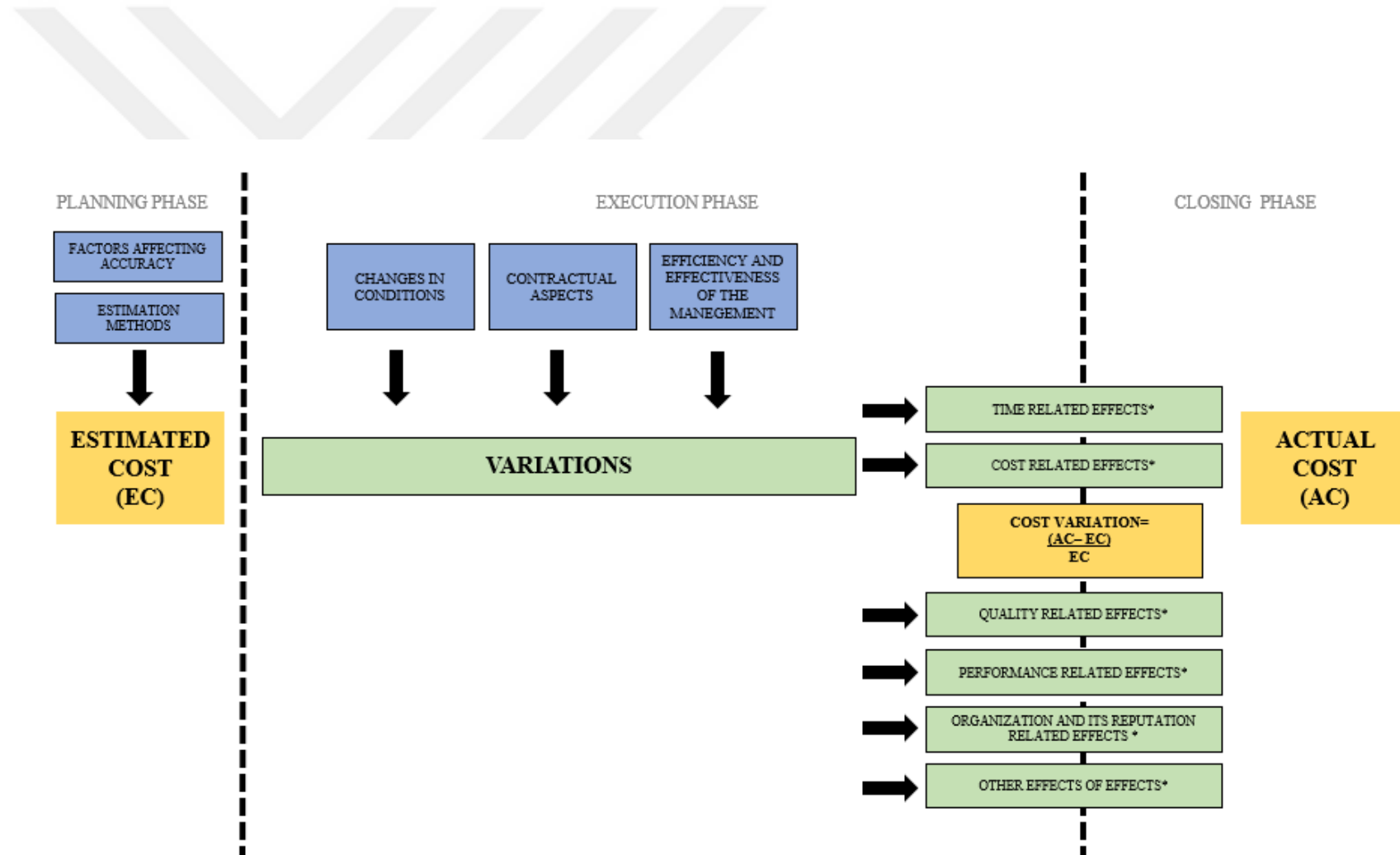
Cost variations are occurred in different Figure 2.1 presents that cost variations between actual cost and estimated cost are affected both in planning phase and in execution phase. Factors affecting accuracy and estimation methods have important effects on estimated cost. Factors such as changes, efficiency and effectiveness of project manament, contractual aspects lead actual cost to differ from estimated cost.

2.1 Causes of Cost Variations

2.1.1 Cost Variations based on changes

Changes in projects are expected and its results are monitored and planned studiously. Modifications in scope, schedule, cost or quality are explained as changes (Ibbs et al., 2007, AIA, 1977). The modifications are agreed with formal documents of the terms of a change or changes between the owner and contractor (Dillard, 1982). Change orders are signed documents of changes in contract scope or time (CSI, 2005). The changes are required whether or not due to obligations or due to the owner's demand. The scope of works can extend by owner or inadequacies in tender preparation can cause changes during the construction. Furthermore, changes may require extension, adjustment or subtraction to provide of the new necessities. For instance, changes may lead the completion date to postpone or increase the source of the budget.

Change control management should be determined at the earlier stages of the project among all of the project participants. Integrated control process should be implemented in order to decide one of the following options; corrective action, preventive action, defect repair (PMI, 2013). The decision throughout action and consequences of changes should be contemplated. Anees (2012) points out that if the changes are not managed by a specified change management they can cause disruption in order of works, decrease in productivity and schedule delays and cost overruns. Isaac and Navon (2008) claimed that capturing the accurate needs of client helps to control the occurrence of changes in construction or the impact of change orders by given tools at



*: The categories are adapted by the study of Keane et al. (2010).

Figure 2.1 The flow chart illustrating the research in the project life cycle.

the beginning of the project. Assuming that schedule and cost changes, caused by design renovations and overdue documents, are not adding any values to project, they may be waste of time, cost and resources (Staiti et al., 2016). Under those circumstances, impacts of the changes should be examined carefully.

The magnitude of the impact and side effects of the cost variations are placing it in a more important position besides, the amount of cost variations due to changes are considerable. Change orders in construction projects cost to Singapore 4.2 billion \$ (12% of construction industry) in 2015 (Nelson and Baker, 2016). It shows that cost overruns not only affect the owner of the construction and the contractor, they also impair the economy of the countries. Change orders also affect the economy through labor productivity. Ibbs and McEniry (2008) exemplify that loss of productivity can be 4000 hours out of a total of 14,000 hours actually worked in a construction that the percent of change orders is 43 and the contract is the fixed price. By reason of the rework and extra working hours due to change orders, the cost varies from estimated cost to the actual cost.

Cost variations occur frequently by the reason of the uncertainties during the change and the difficulty of change management. Touran (2003a) examined six projects in terms of frequency of the changes and impact on the cost of the project. As a result of the calculations, the level of significance of 3 out of 6 projects is merely less than 1%. Serag et al. (2010) claims that change orders increase the cost around 5-10%. Cost growth in 20% of private sector projects, analysed in the study, due to the changes is 11% or more, in this case, this percentage of growth is counted as major changes (Ibbs, 1997). Percentage of the change and percentage of the cost variation differ from project to project, however, the existence of the change in every project and cost effects of changes are certain. Cost overrun for a change order is formulated as follows:

$$\text{Cost Overrun} = \frac{\text{Project cost after change order} - \text{Project original contract value}}{\text{Project original contract value}} \times 100\%$$

(Senouci et al., 2017). Contractors lose money while they think they earn more due to change orders (Ibbs and McEniry, 2008). In addition, contractors are not paid twice since the change has no apparent effect on overhead (Revay, 2003). According to the survey of Staiti et al., 92% of the respondents to guarantee that decrease of the change orders are also decreasing the cost of construction projects (Staiti et al., 2016).

Communication and involvement of all construction parties before the works start on site and coordination of the planning in the design phase can minimize the change orders (Staiti et al., 2016).

The importance of the cost variations arises from its relation with other effects of change orders. Al-Nuaimi et al. (2010) classify the effects of change orders as following headings; delay of schedule, claims and disputes, cost overruns, performance and morale of labor, additional payments for contractors, quality. Cost variations are the most mentioned results by every stakeholder of the project. Gokulkarthi and Gowrishankar (2015) listed effects of change orders by the contractors' perspective as; delay in completion schedule, increase in project cost, increase in contractors overhead, decrease of productivity of workers, additional revenue for contractors. Delay is also an important effect however, it increases overheads and depending on the contract type it also increases labor costs, it can even cause penalty. As a result, cost variations are also caused by other results of change orders.

Changes can be controlled when causes are identified and a defined procedure is executed. Early setting of change order handling procedures is the most ranked control mechanism between listed eleven (Gokulkarthi and Gowrishankar, 2015). Due to changes are common and their impacts are important, there are several types of research on change orders. Researches show that causes of the change orders are defined and categorized by different sources. As it is seen in Keane et al's research (2010), causes of both change order and variations are included in the same categorization. Staiti et al. (2016) state the main causes of change orders are; changes caused by the owner, changes caused by the consultant, changes caused by contractor and additional works. Gunhan and Arditi (2007) categorized causes of change orders in school projects as; changed conditions, owner-directed changes, code compliance issues, errors/omissions and other conditions. All listed factors for cost variations caused by changes are shown in Table 2.1 and they are investigated under followings;

- (1) Changes in works,
- (2) Omissions, and errors in design and construction,
- (3) Other change factors.

2.1.1.1 Changes in works and documents

Changes can occur both in the works at site and in the specialities in the design documents hence both of these changes result in cost variations. The necessity of the changes comes forward to meet the change of the requirements of the users' and additional demands. Therefore the changes can be caused by owner, contractor, consultants or environmental factors. The importance index of the change of plans by owner is calculated 70.59 (Gokulkarthi and Gowrishankar, 2015). For instance from 0.01% to 15% increment in the contract price is caused by change order, which is to provide for major quantity difference (Serag et al., 2010). Owners can change plans, schedule, design, quantities and specifications. When the changes are brought to agenda after the execution of the works or later than the start of the procurement process, changes are documented as change orders. Contractor price the changes with supportive documents and cost variations are controlled. Changes caused by owner not only differ the owners' budget, they change contractors agreed contract value and execution plans which can increase the overhead expenses.

Conditions at site force contractors to make changes during the construction. These changes may not affect the cost of the owner however the cost of the contractor is affected based on the contract conditions.

2.1.1.2 Omissions and errors in works and documents

Design documents and tender conditions are determined and managed by project managers and owners. The accuracy and completeness of the documents decrease the occurrence of the changes in execution phase. As a result of examining both previous studies and case studies, Keane et al. found out that 40% of the most common causes of variation are errors and omissions (2010). Owner defines the scope by the help of project manager. Scope includes the demands of the owner, regularities and the works which is constructed by the contractor. Definition of works and circumstances should be clear in the tender stage. Assuming that there is a conflict between contractor and owner, lack of clarity of scope can be a claim subject for the contractor. Design errors are caused by procurement methods and project types, as a result, design error change the contract value 6,9% directly and 7,4% indirectly (Lopez and Love, 2012). Furthermore, tender documents are the base of contract documentation they need to be

revised during the construction because of incomplete design documents. The revisions of the design documents are directly claim causes for contractors.

The clarified scope is a successful management work, however, the comprehension of the contractor is also important. Incorrect estimation during the tender cause cost variations to the contractor consequently the contractor ends up with financial problems.

Other errors caused by incompetent project members and subcontractors occur in construction site. Methods used in construction should be applicable for design and combination of outdated methods and shortage skills of workmanship cause defective works. Reworks are result in 52% of a project's cost growth and that 26% of the variance in cost growth (Love, 2002). Reworks and technical inadequacies of the construction are the key factors of the quality and cost related changes orders.

2.1.1.3 Other change factors

Environmental, economic and political conditions in the sector and country are the subject of other change factors. Likely monitorable changes, uncontrollable conditions also may be planned before they occur. Changes in economy cannot be controlled however if they are considered in detail, instructions after the changes can be included into contract to avoid any disputes. Bhawsar et al. listed in the following order; escalation of material and labor prices as the most important factors affecting cost overruns of bridge construction (Bhawsar et al., 2016). The fluctuations in the economy and the amount of construction projects available in the market during any particular year may cause the variations on contractor's cost and result in claims and changes (Randolph, 1987). In addition to the economical factors, events depended on social life should be considered and prevention measures should be planned before the construction is affected. Any activity against a public project can be negotiated by all stakeholders of the project and public relations should be planned to reduce the any disagreements as an example. Although the consequences of weather conditions and natural disasters are unexpected by any of the participants, coverage of the insurance of the project can be extended for specific projects. Consequently, environmental, economic and political conditions are unavoidable but the precautions and scenarios can be planned before construction starts.

Table 2.1 : Causes of cost variations due to changes.

Parameters	Reference
Changes in Works and Documents	
Significant changes in the quantities of work	Al-Dubaisi 2000 Senouci et al., 2017 Serag et al., 2010
Change in design request and user needs	Ismail et al., 2012 Senouci et al., 2017 Gokulkarthi and Gowrishankar, 2015 Memon et al., 2010 Jamaludin et al., 2014 Serag et al., 2010 Arain et al.2004 Fisk 1997 Al-Dubaisi 2000 Senouci et al., 2017
Change in specifications	O'Brien 1998 Bhawsar et al., 2016 Gokulkarthi and Gowrishankar, 2015 Chappell and Willis 1996
Change of plans or scope by owner	Ismail et al. 2012 Senouci et al., 2017 Gokulkarthi and Gowrishankar, 2015 Serag et al., 2010 CII 1990b Memon et al., 2010
Owner change of schedule Technology changes	Gokulkarthi and Gowrishankar, 2015 Al-Dubaisi 2000 Senouci et al., 2017 Gokulkarthi and Gowrishankar, 2015 CII 1994b
Differing and unforeseen site conditions	Alnuaimi et al. 2010 Senouci et al., 2017 Gokulkarthi and Gowrishankar, 2015 Serag et al., 2010 Memon et al., 2010
Suggestions to initiate more quality	Ismail et al. 2012 Senouci et al., 2017
Deterioration or damage to the project after the design	Serag et al., 2010
Omissions and Errors in Works and Documents	
Inadequate design	Al-Dubaisi 2000 Senouci et al., 2017 CII 1990a Fisk 1997
Incomplete design drawings and specifications at tendering stage	Bhawsar et al., 2016 Jamaludin et al., 2014
Ambiguous design details	O'Brien 1998
Poor working drawing details	Geok 2002 Arain et al. 2004
Design errors	Egan et al. 2012 Senouci et al., 2017
Inconsistencies in design	Egan et al. 2012 Senouci et al., 2017
Noncompliance of design with owner's requirements	Egan et al. 2012 Senouci et al., 2017

Table 2.1 : Causes of cost variations due to changes.

Parameters	Reference
Omissions and Errors in Works and Documents	
Incompetent project team (designers and contractors)	Bhawsar et al., 2016
Conflict between contract and document	Gokulkarthi and Gowrishankar, 2015 CII 1986
Scope clarity	Gokulkarthi and Gowrishankar, 2015 Sinesilassie et al., 2017
Definition of project objective and formulation at the design phase	Gokulkarthi and Gowrishankar, 2015 Ibbs and Allen 1995 Sinesilassie et al., 2017
Error and omissions in design	Gokulkarthi and Gowrishankar, 2015 Arain et al.2004
Defective workmanship	Gokulkarthi and Gowrishankar, 2015 Fisk 1997 O'Brien 1998 Bhawsar et al., 2016
Mechanical and electrical provision	Yehiel 2014 Senouci et al., 2017
Desired profitability	O'Brien 1998
Inappropriate construction methods	Bhawsar et al., 2016
Other Change Factors	
Unknown geological conditions	Akinci and Fischer, 1998
Unforeseen problems	Clough and Sears 1994 O'Brien 1998
Weather condition	Gokulkarthi and Gowrishankar, 2015 Fisk 1997 O'Brien 1998 Akinci and Fischer, 1998 Sinesilassie et al., 2017
Natural disasters (flood, hurricane, earthquake)	Bhawsar et al., 2016
Local government policy	Al-Dubaisi 2000 Senouci et al., 2017 Akinci and Fischer, 1998
Utility companies	Al-Dubaisi 2000 Senouci et al., 2017
Hostile social and economic environment	Sinesilassie et al., 2017
New government regulations	Gokulkarthi and Gowrishankar, 2015
Safety consideration	Gokulkarthi and Gowrishankar, 2015 Al-Dubaisi 2000 Senouci et al., 2017 Clough and Sears 1994
Change in economic conditions	Akinci and Fischer, 1998
escalation of material, machinery and labor prices	Fisk 1997 Bhawsar et al., 2016 Jamaludin et al., 2014 Memon et al., 2010
High cost of labor	Bhawsar et al., 2016 Jamaludin et al., 2014
High cost of transportation	Bhawsar et al., 2016
Nature of the firm's operation.	Akinci and Fischer, 1998
Regional and external factors.	Akinci and Fischer, 1998
Nationalists' attitude towards the firm.	Akinci and Fischer, 1998
Influence of power groups	Akinci and Fischer, 1998
Project desirability	Akinci and Fischer, 1998

2.1.2 Cost Variations based on contract

Construction projects are complex and open to conflicts, therefore, requirements of the specified works and services need to be agreed for each participant. Contract management process is conducted by the project team in case of development and administration of contracts. According to PMI (2013):

A contract represents a mutually binding agreement that obligates the seller to provide something of value (e.g., specified products, services, or results) and obligates the buyer to provide monetary or other valuable compensation. An agreement can be simple or complex and may reflect the simplicity or complexity of the deliverables or required effort.

Type of the contract is determined based on the procurement method. Each project has a different organization and different circumstances in terms of coordination between participants, the hierarchy of the team members, contractual relations, design and method of the construction.

Procurement method specifies all of the process and the procedures during the construction. Specified procurement method shows a management system to conduct the construction. Due to the different requirement of owner or project conditions, each project procurement system has unique relationships. Four main category titles of the procurement systems are: traditional, design and build, management and collaborative (CRC, 2008) Traditional systems are fixed-price contracts, cost-plus contracts and unit price contracts. Design and build system is managed by the owner with one contractor including the design. In the management system, Project Manager is included in all process either as a contract manager or as a consultant. The collaborative system is an integrated relation system which is defined for the project specifically. Shortly explained types of the system and the contracts are shown in Table 2.2.

Inappropriate procurement type may result in an unsuccessful project. Appropriate procurement and contract method are selected by the expectations of the project. Procurement strategy is specified by the following factors: external factors, client resources, project characteristics, cost, ability to make changes, cost issues, timing (CRC, 2008). Rowlinson and Newcombe (1984) have investigated contract types in terms of estimated cost certainty, cost level, coordination of team, change adaptability, buildability and time. Hibberd and Djebarni (2016) conducted a survey to determine

the most significant selection criteria consequently found out that predictable cost, accountability, and speed in completion are the most ranked criteria. As it is seen in the previous studies, cost and cost effect of changes are considered for selection of procurement type.

Each contract type has different approaches to the chances and risk at construction. The average amount of change that calculated by labor hours as the contract clause for 226 projects was 8% and converted in change orders. (Ibbs, 2012). For instance, some of the contract types impute the risk to the contractor such as design and build contract, however, the risk is taken by owner and project managers in other types of contracts such as Cost Plus Fixed Percentage. Type of the delivery method changes the use of a contingency for the contractor's (Hart and AIA, 2007). Fixed price payment type of contracts and pressure on the purchasing agreements are suggested for fit-out contractors to lower their margin under 20-30% to get the best price and clarify the uncertainties due to the changes (Oktra, 2018). Semple et al. (1994) found that 11 lump sum contracts had 44% cost increase and eight unit price contracts had an 88% cost increase. Alternative forms of procurement method such as partnering and alliancing come out to reduce the disputes by time and costs overruns and increase the project success. (Love et al.,1998). In conclusion, shifting the risk between participants change the value of the actual cost at the end of the project based on contract types.

Contracts are signed documents between the owner and contractor to construct the project and between owner and architects and engineers to design it. Contract procedures and forms can be obtained from AIA Document G612, Owner's Instructions Regarding the Construction Contract, Insurance and Bonds, and Bidding Procedures. Therefore contracts are the list of documents that include the following:

- Contracting forms
 - Notice of award
 - Agreement
 - Attachments to agreement
- Project forms
 - Bond forms
 - Certificates and other forms

- Clarification and modification forms
- Closeout forms
- Conditions of the contract
 - Contracting definitions
 - General conditions
 - Supplementary conditions
- Revisions, clarifications, and modifications
 - Precontract revisions, including addenda
 - Record clarifications and proposals
 - Record contract modifications (CSI, 2005).

All of these documents in contract specify the procedures in case of any changes. The process is followed to calculate the cost of the revisions, to assign the rights of the contractor have due to effects of changes. The contractor has to present a claim for the consequences of the changes to the owner or project manager before taking any action. In addition to the cost of new works, loss of profit, loss and expense and damages are also included within the claims. The scope and limitations of the contract should be clarified by the participants to avoid the disputes (Othman, 1997). Contracts are also negotiator when there is a contention between participants. Defined change conditions need to redound both of the participants' benefits in order to avoid any conflict. Othman (1997) claims that the main areas of contention are related to time and money issues.

Table 2.2 : Sum of procurement and contract types.

Traditional System Design Bid Build	Fixed Price
	Cost Plus Fixed Percentage
	Cost Plus Fixed Fee
	Cost Plus with Guaranteed Maximum Price Contract
	Cost Plus with Guaranteed Maximum Price And Bonus Contract
	Unit Price
Design and Build System	
Construction Management System	
Collaborative System Integrated Project Delivery	

Table 2.3 : Causes of cost variations due to contract.

Parameters	Reference
Type of Contract	Akinci and Fischer, 1998
Context of Contract	Akinci and Fischer, 1998
Length of Implementation	Flyvbjerg et al., 2004
Type of Ownership	Flyvbjerg et al., 2004
Size of the project	Flyvbjerg et al., 2004
Fast-track construction	Fisk 1997

2.1.3 Cost Variations based on project management

Cost variations are basically caused by unexpected or changed situations unlikely a project team planned. A project is defined as a process from the planning phase to operation phase of a building furthermore, a successful project occurs with a well-communicated team during this process (CSI, 2005). The project team is responsible for the response of the occurred events. The ability to handle the situation is important for the following effects of the variations. on the other hand, the variation may be caused by an event or a decision in the planning phase. All process should include the required management and teamwork to achieve success.

Definitions of project management practice by different authorities are given following:

The British Standard for project management BS60794 (1996) defined project management as:

The planning, monitoring, and control of all aspects of a project and the motivation of all those involved in it to achieve the project objectives on time and to the specified cost, quality, and performance.

The UK Association of Project Management (APM) (1995) have produced a UK Body of Knowledge UK (BoK)⁵ defined project management as:

The planning, organization, monitoring, and control of all aspects of a project and the motivation of all involved to achieve the project objectives safely and

within the agreed time, cost and performance criteria. The project manager is the single point of responsibility for achieving this.

Cost effects of the change or unexpected event is one of the calculable effects of variations. Experienced project management team calculate the amount of the cost variation in order to make easier the decision-making. Changes or variations are not unstoppable actions. They should be examined and an action plan should be applied. Memon et al. (2012) established that the cost overrun in Malaysia projects are highly encountered besides participants of the teams acquiesce to the variations. A project may fail or it may not succeed in terms of each criterion however the acceptance of the occurred results cause the next project to fail again.

Each member of any team involved in the project should be competence for their position. Each stage of the construction should be planned with each participant of the project. Therefore participants add value to the planning by their experiences. Contractors prefer inexperienced employees due to low salary, however, the inadequacy of these employees easily affect the rest of the team and decrease success (Jamaludin et al., 2014).

Mistakes due to poor management may be caused in the planning phase or execution phase. Management performance during the execution phase is essential in order to take action for problems. An inappropriate plan is, however, prevent all works to diverge and fail during the construction. Incomplete design or tender documents in planning phase cause changes in the execution phase. Therefore, the cost variations due to scope changes or claims are seen frequently. Another encountered but ignored the problem is communication. Neither in the planning phase nor in the rest of the process the effect of communication should be considered. The project team should work in cooperatively.

Management based causes of the variations are reasonably important for the success of the project. The reason is that management should be inserted in during all process constantly. The results of questionnaire, conducted with 37 senior level project management consultant, shows that cash flow and financial difficulties faced by contractors, contractor's poor site management and supervision, inadequate contractor experience, shortage of site workers and incorrect planning and scheduling by contractors are significant factors affecting construction cost (Memon et al., 2010).

Bhawsar et al. and Sinesilassie et al. presented many managerial causes for the cost variations (Bhawsar et al., 2016) (Sinesilassie et al., 2017). Each factor is grouped into four categories in Table 2.4. The importance and the reasoning for each category are presented below.

2.1.3.1 Poor management

Poor site management and supervision: Site coordination plan and organization chart of the project is prepared by the contractor to avoid confusion. Position and role of every participant in the project are specified in order to monitor works. Monitoring on-site is essential for detecting defective or unfinished works earlier. The progress of the project is affected by poor site management of contractor including the frequent change of site manager, poor communications with the subcontractors and to be late in requirements of the site (Memon et al., 2010).

Construction planning not only management subject but also the technical necessity. Insufficient plan or incorrect plan cause works to delay or overlap since every work has a correlation with others. Thus, they affect each other and they may cause a delay in the completion date. Shifting in completion day cost both contractor and owner. On the other hand, lack of cost planning and monitoring during contract stages and lack of strategic planning is an omission in the management.

Financial problems faced by the contractor indicate the execution of the project plan. in case that contractor cannot afford the effectual number of workers or have problems to keep subcontractors in the site because of delayed payments, it results in schedule delay and cost variations. The contractor prepares cash flow and payment schedule in construction. The payments are usually gain by submission of milestone works and obtained payments are used for advances or payment of subcontractors. Delay of payment schedule conduce subcontractors, even workers, to go on a strike. Site management is ensured by the contractor. Workers supplied by subcontractors are the main reasons for the recession in case of any dispute between the contractor and subcontractor (Memon et al., 2010).

In addition to the planning, technical specifications and new methods need to be adapted into construction. The uniqueness of the project activities requiring high technical know-how is a requirement of a specific type of project. It is also experienced

based knowledge to lead the construction. Lack of this knowledge may entail participants to solve technical problems in ways that are more expensive.

2.1.3.2 Lack of coordination and communication

Both coordination and communication of the participants are required in every phase of the project. Lack of these two relation cause omissions for projects needs and it affects unclear scope. It can be seen that coordination and communication are indirect but affecting factors on cost variations. Designers should use the modification procedures and they should substantiate the data required for claims for extra costs in a Division 01 section of the specifications to avoid the difficulties caused by lack of communication cause besides the schedule of values and the construction progress schedule should be adjusted to reflect the appropriate changes by the contractor (CSI, 2005). Weekly or monthly and regular or special meetings are necessary for every project. The subject of these meetings is control and decision points for unexpected cases. Delay of the decisions is the reason for the delay of the completion time and increment on cost.

Role of the owner is not only financial but also decision making. Project Manager can solve detected decisions however the design should be approved by the owner because it reflects the owner's need. Relation of time and the cost of a project is explained various times. Therefore promptness of the decision reduces the time of the project and cost of the project as well.

2.1.3.3 Experience of the stakeholders

Experience in the specific type of project or familiarity with the regulation helps planning. It is the reason that contractor and owner are aware of obligatory and they get prepared for the permissions or certificates in every phase. The ignorance of these regulations results in penalties or laying off the site works.

Incompetent team cause omission and deficiency in their works. Every forgotten detail is the reason for rework and claims, which have usually cost effects. Detection of the appropriate contractor for the project requires a preliminary investigation. The convenience of contractor originates from its skills, experience and financial power. Competent project manager conducts coordination and all participants of the project easily. Project manager's desire and motivation is important to link the coordination

Table 2.4 : Cost variations due to project management

Parameters	Reference
Poor site management and supervision	Bhawsar et al., 2016 Memon et al., 2010
Incorrect planning and scheduling by contractors	Serdar et al. 2012 Senouci et al., 2017 Bhawsar et al., 2016 Jamaludin et al., 2014 Memon et al., 2010
Schedule delays in the project	Al-Najjar 2008 Senouci et al., 2017 Memon et al., 2010
Lack of strategic planning	Clough and Sears 1994 Bhawsar et al., 2016
Lack of cost planning/monitoring during pre and post contract stages	Bhawsar et al., 2016
Project manager's ignorance and lack of knowledge	Sinesilassie et al., 2017
Value engineering	Gokulkarthi and Gowrishankar, 2015 Dell'Isola 1982
Long-lead procurement	Fisk 1997
Poor procurement process	Fisk 1997
The practice of assigning the contract to the lowest bidder	Memon et al., 2010
Financial problems	Thomas and Napolitan 1995 Bhawsar et al., 2016
Contractor desire to improve his financial conditions	Gokulkarthi and Gowrishankar, 2015
Contractor's Cash flow and financial difficulties	Gokulkarthi and Gowrishankar, 2015 Jamaludin et al., 2014 Memon et al., 2010 Bhawsar et al., 2016
Owner financial difficulties	Gokulkarthi and Gowrishankar, 2015 Clough and Sears 1994 O'Brien 1998
Delay in Material procurement	Memon et al., 2010
Delay in progress payments	Bhawsar et al., 2016
Absenteeism of labor	Bhawsar et al., 2016 Memon et al., 2010
Availability of resources (fund, machinery, materials, etc.) as planned throughout the project	Al-Najjar 2008 Senouci et al., 2017 Geok 2002
Delay in obtaining permits from the municipality	Bhawsar et al., 2016
Delay in providing services from utilities (such as water, electricity)	Bhawsar et al., 2016
Unreliable Subcontractor-Generated Risk Factors	Akinci and Fischer, 1998 Bhawsar et al., 2016
Complex design and technology	Arain 2002 Arain et al.2004 Fisk 1997 Bhawsar et al., 2016
Project Specific Factors	Sinesilassie et al., 2017

Table 2.5 : Cost variations due to project management

Parameters	Reference
Lack of Coordination and Communication	
Lack of communication	Arain et al. 2004 Memon et al., 2010 Gokulkarthi and Gowrishankar, 2015 Sinesilassie et al., 2017
Lack of coordination	Arain et al. 2004 Bhawsar et al., 2016 Jamaludin et al., 2014 Sinesilassie et al., 2017
Insufficient planning at the project definition stage, or lack of involvement of the owner in the design phase	Arain et al. 2004
Tendency to pass on the blame to others	Sinesilassie et al., 2017
Conflicts among project participants	Sinesilassie et al., 2017 Mahamid et al. 2013 Senouci et al., 2017
Obstinate nature and dissatisfaction of owner	Wang 2000 Arain et al. 2004
Indecisiveness of project participant and holding key decisions in abeyance	Sanvido et al. 1997 Gray and Hughes 2001
Impediment of prompt decision-making process	Memon et al., 2010
Late in reviewing and approving design documents	Sinesilassie et al., 2017 Bhawsar et al., 2016
Experience of the Stakeholders'	
Lack of experience of local regulation	Bhawsar et al., 2016
Lack of experience of similar projects	Bhawsar et al., 2016 Jamaludin et al., 2014
Incompetent Project team (designers and contractors)	Bhawsar et al., 2016 Memon et al., 2010 Arain et al. 2004 Gokulkarthi and Gowrishankar, 2015
Consultant's lack of judgment and experience	Ismail et al. 2012 Senouci et al., 2017 Bhawsar et al., 2016
Contractor's lack of judgment and experience	Ismail et al. 2012 Senouci et al., 2017 Memon et al., 2010
Project manager's competence	Sinesilassie et al., 2017
Owner's incompetence	Sinesilassie et al., 2017
Monitoring During the Construction	
Monitoring and feedback	Sinesilassie et al., 2017 Jamaludin et al., 2014
Unavailability of equipment	Gokulkarthi and Gowrishankar, 2015 O'Brien 1998
Slow mobilization of equipment	Bhawsar et al., 2016
Shortage of equipment	Bhawsar et al., 2016
Inadequate modern equipment	Bhawsar et al., 2016
Low efficiency of equipment	Bhawsar et al., 2016
Quality control and assurance	Sinesilassie et al., 2017 Bhawsar et al., 2016
Scrape and rework	Jamaludin et al., 2014

among the participants. Lack of coordination and communication is also mentioned above. Up-to-date tools and techniques in management are essential to acquire a successful project in the market conditions. For instance, Project Manager should evolve techniques they use in order to estimate the owner's contingency. The speed of the construction is expedited day by day, outdated management techniques cannot follow decisions in time. Specific projects need specific techniques and technologic tools in the construction. Project Manager's lack of interest to the process results in absence of some requirement for operating procedures.

2.1.3.4 Monitoring during the construction

Project management and cost control process includes both monitoring and feedback actions. The process should be monitored sequentially to renew the estimated cost to achieve actual cost. In addition to cost monitoring, quality and health and safety issues need to be monitored. For instance; oversight quality problems cause rework and extra cost to the contractor. Furthermore, ignorance in health and safety regulations may result in death and injuries which have legal enforcement effects.

Another aim of the monitoring is to compare schedule and works site. Delay in the mobilization of equipment or speed of the works may cause the delay on the completion date. In this cases, preventive actions need to be planned and applied.

2.1.4 Cost Variations based on cost estimation

2.1.4.1 Factors of accurate cost estimation

Cost estimating is an essential phase to predict the cost of the construction. Cost estimation is prepared at different levels of the project and for different purposes. The study of Akintoye and Fitzgerald (2000) had been examined the uses of the cost estimate and it is found that preparation of the tender for the client is the most common usage of the cost estimates. Cost estimation process has various parameters to take into consideration, on the other hand, the lowest bid is the reference cost for the client (Serpell, 2004). It proves the need for a professional and experienced evaluation for an accurate estimation.

The accuracy of the cost estimation is the essential point for a successful project. Accuracy is the nearness of the estimated cost to the actual cost of a project. It is assumed that the change in the estimated cost based on a reference value is an

estimating error (Serpell, 2004). Accurate estimation leads the project to finalize in the most economical ways while an underestimation or an overestimation leading the actual cost to the deviation. (Enshassi et al., 2013). Although accurate estimation is important, many factors cause the actual cost to differ from initial estimates (Hatamleh et al., 2018). The measure of success and performance of both project and the project team is the comparison of actual cost to early cost estimates (Oberlender and Trost, 2001).

The level of accuracy differs in every phase of the project and based on different factors. As the project progresses estimation accuracy increase through the project life cycle (PMI, 2013). According to Arditi et al. (2002), although the estimation process starts in the design phase it is completed in the construction phase. Cost estimation process may affect different factor and inaccurate estimations can occur. Estimators' experience inadequacy, the speed of the estimation process, lack of documentation in tender process and incoherence of subcontractors' prices are detected as the major causes of inaccurate estimation (Akintoye and Fitzgerald, 2000) (Arditi et al., 2002). Additionally, inaccuracy of estimation is a combination of other factors such as; unknown site conditions, provisional sums allocation, and their rationale and the suitability of historical cost data (Lim et al., 2016). Characteristics of the client, consultant, and the contractor are lack of precision and uncertainty, however, they are important as other factors. Combinations and relationships of affecting factors, the complexity of construction process and uncertainty of data are problems that cause deficiency an estimation process (Elhag and Boussabaine, 1998).

Several factors that were defined through different sources for the accuracy of cost estimation should be considered. Accurately estimation of the project cost is competence in cost-based competition. Estimation methods are considered common, however, the specific qualifications of each project phase are underestimated (Liu and Zhu, 2007) Liu and Zhu focused on the crucial factors on cost estimation by project phases (Liu and Zhu, 2007). Akinci and Fischer collected factors that are directly related with cost in two groups: estimator-specific, and design and project-specific factors. (Akinci and Fischer, 2003). In addition to these, two groups of factors, Lim et al. (2016) mentioned environmental factors affecting the accuracy of cost estimation. Elhag and Boussabaine (1998) also list unrelated factors from project characteristics such as market condition, number of bidders and lowest tender price. For example, the

competition between bidder companies during the tender process is a remarkable factor for the proposed quotation, therefore, the contractor needs to inquire about its competitors and review its estimated cost. Furthermore, Touran proposed an approach remarkably easy to use and depends on only a few important variables including coefficient of variation of cost of change Cantarelli et al. (2012) had focused variations caused by project type, project size and the implementation phase in the research. The similar type of projects is evaluated by historical cost data from previous projects through priced bills, cost analyses and published data (Doyle and Hughes, 2000).

Table 2.1 is created by combining the factors mentioned and all factors are grouped into three categories mentioned before: project-specific factors, environmental factors, estimator specific factors.

Project-specific factors

Project-specific factors on the accuracy of cost estimation depend on conditions directly related to design the project site or project tendering specifications. in Table 2.1, parameters under project-specific category are collected through various researches.

Project design criteria and data are determinant for the estimation process. For instance, the type of project is one of the most compared factors. Percentages of cost overruns and cost underruns are different in the road, rail and fixed links projects (Cantarelli et al., 2012). It is shown that while the average change of the new street construction is 5.35, the average change mean of the sewer construction is 9.03 and sidewalk repair is 1.93 (Randolph, 1987). Each project is priced through a bill of quantity breakdown. Consequently, as the size of the projected increase, the quantity of the works are increased and the estimated cost changes. The size of the project can be evaluated by followings; ground floor area, no of stories, no of column, type of foundation, no of rooms (Elfaki et al., 2014)(Elhag and Boussabaine, 1998)(Cantarelli et al., 2012)(Lim et al., 2016)(Jahren and Ashe, 1990)(Arafa and Alqedra)(Akinci and Fischer, 1998). Every different work and material of the project is a reason to ambiguity in construction hence changes in undefined or indecisive design are expected. Requirements and obligatory of a building construction and an infrastructure construction define its own specific works (Elfaki et al., 2014).

The materials used, the technology included in construction, the techniques of application are defined by obligatory of the project. Project team depending on project design and site conditions designs construction techniques. The site conditions are cost influencing factors to run an estimation model (Elhag and Boussabaine, 1998).

Tender documents and procedures are also effective on the accuracy of estimation. Although the information is defined by current design and project specialties, the reliability of data coming from vendors, designers, and other sources and their collaboration to the sharing it is another factor (Serpell, 2004). The duration of the design, process or insufficient people who involved in the preparation of tender documentation is the reason behind the undefined and confusing information. Clarity of the design documents and the precision of tender documents are effective on the accuracy of the estimation (Lim et al., 2016). As long as the contractors schedule their management and master the details, it is easier and more accurate to estimate the cost of the intended project.

Estimator specific factors

Estimators gather information from designers and client, however; it is analysed and converted into an estimation. Experience of the estimator is a consensus impact on cost estimation. Cost performance is increased when the project manager has previous projects are likely in terms of the scope of work (Sinesilassie et al., 2017). It is inherent that estimators also affected by several factors. There are three factors that affect the estimator's performance; the experience of the estimator, the effort of estimator on work and personality of the estimator (Serpell, 2004). What makes experience valuable is a combination of knowledge from different areas. The aim of the estimation is to foresee the actions in the future and the ability to overcome uncertainties is a personal characteristic.

The experience of the estimator should not be only quoting a price, preparing risk models, and analyzing data. in addition to the experience of the estimators' on their own area, it is also important to have the ability of the site control furthermore the contractors should arrange for a training for that. (Akintoye and Fitzgerald, 2000). As estimators are familiar with the site practices, they can predict different scenarios. For

Table 2.6 : Factors affecting accuracy of cost estimation.

Category	Reference	Parameters	Reference
Design and Project-Specific Factors	Elfaki et al., 2014	Size	Elfaki et al., 2014
	Akinci and Fischer, 1998	Ground Floor Area	Elhag and Boussabaine, 1998
	Lim et al., 2016	No Of Storeys	Cantarelli et al., 2012
		No Of Column	Lim et al., 2016
		Type Of Foundation	Jahren and Ashe, 1990
		No Of Rooms	Arafa and Alqedra, 2011
			Akinci and Fischer, 1998
		Type Of Project	Elfaki et al., 2014
			Cantarelli et al., 2012
			Randolph, 1987
			Elhag and Boussabaine, 1998
			Lim et al., 2016
		Ground conditions	Elfaki et al., 2014
			Elhag and Boussabaine, 1998
			Lim et al., 2016
		Site Slope	Elhag and Boussabaine, 1998
		Excavation Conditions	Elhag and Boussabaine, 1998
		Site Access	Elhag and Boussabaine, 1998
		Work Space in Site	Elhag and Boussabaine, 1998
		Type Of Client	Elfaki et al., 2014
		Design and Scope Changes	Elfaki et al., 2014
		Scope Quality	Serpell, 2004
		Contract Type	Elfaki et al., 2014
			Elhag and Boussabaine, 1998
			Lim et al., 2016
		Tendering Method	Elfaki et al., 2014
		Material Cost	Elfaki et al., 2014
		Cost Of Skeleton	Arafa and Alqedra, 2011
		Construction Method	Lim et al., 2016
			Jahren and Ashe, 1990
		Duration	Elfaki et al., 2014
			Elhag and Boussabaine, 1998
			Lim et al., 2016
		Phase	Cantarelli et al., 2012
		Start Conditions	Elhag and Boussabaine, 1998
		Uncertainty Level	Serpell, 2004
		Complexity Of Project	Lim et al., 2016
			Akinci and Fischer, 1998
		Quality Of Estimating Procedure	Serpell, 2004
			Lim et al., 2016
		Information Quality	Serpell, 2004
		Design Data	Lim et al., 2016

Table 2.6 : Factors affecting accuracy of cost estimation.

Category	Reference	Parameters	Reference
Estimator-Specific Factors	Elfaki et al., 2014	Estimator Performance	
	Akinci and Fischer, 1998	Estimator's Experience	
	Serpell, 2004	Coefficient Of Variation Of Cost Of Change	Touran, 2003b.
	Lim et al., 2016	Historical Data	Doyle and Hughes, 2000
Environmental Factors	Lim et al., 2016	Market Condition	Lim et al., 2016
			Elhag and Boussabaine, 1998
		Number Of Bidders	Lim et al., 2016
			Elhag and Boussabaine, 1998
			Jahren and Ashe, 1990
		Lowest Tender Price	Elhag and Boussabaine, 1998
		Reduction Of Supply	Lim et al., 2016
		Financial Uncertainty	Lim et al., 2016
		Good/Bad Years	Lim et al., 2016
		Level Of Construction Activity	Lim et al., 2016
		Weather Conditions	Lim et al., 2016
		Labour Cost/Availability	Lim et al., 2016

example, assuming that the details in design documents are insufficient to apply a material to the concrete, a site-experienced estimator would include additional fittings in the cost. on the other hand, an experienced estimator could insist on providing benefit from their own experiences instead of using reformist and ingenious tools and techniques (Lim et al., 2016). The desire to diffuse other knowledge areas should be adopted by the estimator. Every day researchers find a new technique or combine the accepted models to attain more accurate cost estimations. Another role of estimators' is to calculate the contingency of the owner which is account for the risk of the project (Hart and AIA, 2007) Risk management is completely wide knowledge and experience area in construction. Up to date methods and knowledge, areas are subjects of not only construction but also project management.

Environmental factors

Having design parameters and analyzing them with an experienced estimator is not the complete formula of an accurate cost estimation. The construction project is an execution process for a scheduled plan however other conditions among project specifications are needed to consider. Reduction of supply, financial uncertainty and

other changes in market conditions are described as environmental uncertainty (Serpell, 2004). Likewise, Doyle and Hughes specify general factors as the level of risk and uncertainty in the project, regional variations, market forces and collusive tendering (Doyle and Hughes, 2000). The economic circumstances in the market and the impacts of political changes cause a direct modification in the scheduled plan. The change rate of currency is a direct factor on cost changes, for instance.

There are also uncontrollable but indirect factors for the accuracy of the cost estimation. The significance of these factors is weather conditions. The relation between cost and weather forecast is not directly effective nonetheless; underestimation of this factor and incautiousness at the site can result in the unexpected cost.

Changes in macroeconomics can or cannot be estimated, however, other factors in the construction market are as important as factors uncontrollable. Although there is not any study that evaluates the impact of the competition between contractors, it is one of the factors on cost deviations and equally affects the change order rate. (Jahren and Ashe, 1990). Instead of out of control conditions, the willingness of other competitors to get the project is a matter of contemplation. The lowest bid for the tender is used to set up the adjusted tender price, also the number of tenderers is also considered as an accuracy factor (Elhag and Boussabaine, 1998). From the owners' perspective, the difference between proposed bids is important for a choice of the contractor. In the research that Randolph conducted the difference between the low bid and the owner's estimate size are considered when the projects are categorized and it is established that standard deviation of the bids have relation with the project attributes (Randolph, 1987).

Whether or not environmental factors of accurate estimation are direct or indirect they are uncontrollable. Keeping up with these changes or factors is also a task for estimators. Consequently, project conditions and estimators' experience are completed with the consideration of the environmental factors.

2.1.4.2 Methods of cost estimation

Cost estimating is the precise process of the project for several purposes. The study of Akintoye and Fitzgerald (2000) had been examined the uses of the cost estimate and the preparation of the tender for the client is found as the most common usage of the

cost estimates. Every purpose and the phase of the estimation is done required different aspects. Various methods of calculation are searched to attain the most accurate cost estimation. Arafa and Alqedra mentioned the existence of different methods and techniques such as; traditional detailed breakdown cost estimation, simplifies breakdown cost estimation, cost estimation per activity; cost estimation based on cost functions, index number estimate, expert systems (Arafa and Alqedra, 2011).

The cost estimating should predict risks and uncertainties during the construction. The sources of the cost for additional works and changes is called: contingency. In consideration of unforeseen conditions and meeting their cost, contingencies are added as an extra source into the budget (Gunhan and Arditi, 2007). *“A contingency is a predetermined amount or percentage of the contract held for unpredictable changes in the project. A contingency is a helpful risk management tool that financially prepares owners for addressing risk within the project”* (Hart and AIA, 2007). Designers include contingencies at the preliminary and final design stages starting from 20-30 percentages, nevertheless, the bid price of contractors are expected to have 0 percent (Arditi et al., 2002). Contingencies are defined in different sources. The owners see the contingencies as a reserved part of the budget for the uncertainties during construction (Touran, 2003b). Not only owners have contingencies in the budget but also designers and contractors have. To meet preconstruction cost increases designer contingency is added in the preliminary budget and contractor contingency conduct the unexpected events during the construction phase (Gunhan and Arditi, 2007). Owner's, contractor's and designer's, contingency are included in the budget for the same purpose that to complete the project on the budget (Hart and AIA, 2007). Each participant of the project is using his or her own methods for the cost estimation. Contractors use conventional and traditional techniques; as well, there is a tendency to achieve cost estimation by pricing the labor, materials, plant, subcontractors, and overheads (Akintoye and Fitzgerald, 2000).

Although bidding or determining the project budget is essential, to decrease the expected cost is very important. Both to estimate the budget and to reduce the contingency are set as objectives in the proposed methodology (Gunhan and Arditi, 2007). Achieving all of the construction information and making design and bidding documents definite contribute to minimizing, inaccuracies (Arditi et al., 2002).

All of these contingency types are the consequences for different needs, therefore; the method of the estimation should be chosen correspondingly the aim of the budget. Some of the techniques are easy and practical while others need more information and knowledge for estimation. As it is complicated to find quantified effects of accuracy factors, a determined percentage of the estimated cost is added as a fixed value into the budget by the way of previous experiences (Touran, 2003b). Using previous experiences is one of the most common approaches. on the contrary to simple methods, Touran conducted change orders in a Poisson process to distribute the cost of the change orders both identically and separately in other variables as a statistical model (2003a). Accuracy factors that are taken from a conceptual estimating survey, experts' interviews and a literature review are used to create a qualitative causal model (Serpell, 2004).

Skitmore (1989) is stated and defined the usage of four types of estimation methods that are Standard Regression approach, CPS simulation, ELSIE, Bidding Model Debiaser. (Skitmore and Brendon, 1989). Boussabaine and Elhag (1998) explained the deficiencies of known methods in literature and suggested Artificial Neural Networks (ANNs) contrary to traditional methods. (Elhag and Boussabaine, 1998) Serpell (2004) subsume under two categories. The evaluation of estimation quality can depend on two categories;

- Data based methods: previous project information and quantitative models are used for estimation.
- Judgmental-based methods: single experience are obtained and produced for valuation. (Serpell, 2004)

Elfaki at al. (2014) grouped intelligent construction cost estimation methods into five categories based on their techniques. in addition, Elfaki at al. (2014) investigated the factors used in the techniques and the validation of each group. (Elfaki et al., 2014)

Table 2.2 list the techniques and models mentioned in previous studies.

Table 2.7 : Cost estimation techniques proposed in previous studies.

Techniques Defined	Referred By
Linear / Dynamic Programming, Regression Analysis, Simulation / Risk Analysis, Expert Systems	Elhag and Boussabaine, 1998
Machine Learning Systems. Knowledge-Based Systems Evolutionary Systems Agent-Based System Hybrid Systems	Elfaki et al., 2014
Standart Regression Approach Cps Simulation Elsie Bidding Model Debiaser	Skitmore and Brendon, 1989
Data-Based Methods Judgmental-Based Methods	Serpell, 2004
Estimating Standard Procedure Comparison With Similar Past Projects Based on Personal Experience Comparison With Similar Past Projects Based on Documented Facts Establish Standards Intuition A Simple Arithmetic Formula Usage Of Software For Estimating Published Price Information Capital Estimating Factors Shared Information With Subsidiary Of The Firm Range Estimating (Based on Probabilistic Technique) Guessing Shared Information From Other Construction Firms A Complex Statistical Formula	Akintoye and Fitzgerald, 2000

2.2 Effects of Variations and Change Orders

Change orders during the execution phase are requested in order to enhance the design or functions of the building. Despite the expected advantages of the change orders, the effects of the changes cause several variations as a result. Variations on project goals should not be ignored and utility of the requested changes should be judged through all consequences. A material change due to esthetic concerns can cause additional works which increase cost and delay the schedule. The necessity of the changes should be questioned in this case.

The impacts of the variations and change orders are the main concern of all stakeholders'. Mitigation of the impact of the consequences of variations is important. There are several types of research that have been conducted to find the causes of the cost variation are aimed to reduce the impacts. New control mechanisms are searched and several techniques are applied to construction for the same purpose.

Effects of the variations and changes can result in different areas. Cost variations and change orders have several effects besides the causes are quite a number. Thomas and Napolitan (1995) analysed different change variables with one accord in order to calculate the impact of changes besides result of the examinations showed that there is a 30% loss of efficiency. Intensity, timing in relation to project duration, work type, type of impact, project phase and management on site are influenced factors of the impact of change orders on labor productivity (Moselhi et al., 2005) Projects with more change generally have a lower Productivity Index. (Ibbs, 2012). Productivity level is a parameter to schedule the works, the planned schedule cannot be achieved with less productivity than expected. Changes for materials and work activities in contract usually result in claims and disputes, especially in developing countries, due to the confusion and disruption (Al-Nuaimi et al., 2010). Two main effects of the change orders are cost overruns and time overruns (Staiti et al., 2016)(Gokulkarthi and Gowrishankar, 2015). In addition to the most ranked two effects, the quality, the performance, and organization and its reputation-related effects are searched numerous times.

Despite the fact that the mentioned effects are astride areas, their effects on each other are notable. Dependence of the length of the project and cost overruns is proved by calculations further, the increase of cost variation caused by the length of the

Table 2.8 : Effects of cost variations

Category	Reference	Parameters	Reference
Time Related Effects	Keane et al., 2010	Delay in Payment Delay Completion Date Of Projects Procurement Delay Rework and Demolition Labour Productivity Logistic Delay Delay of Material and Tools Work on Hold. Delay Completion Schedule	CII 1990a Al-Nuaimi et al., 2010, O'Brien 1998 Clough and Sears 1994, CII 1990a Thomas and Napolitan, 1995, Fisk 1997, Gokulkarthi and Gowrishankar, 2015, Gokulkarthi and Gowrishankar, 2015 Ibbs 1997, Gokulkarthi and Gowrishankar, 2015,
Cost-Related Effects	Keane et al., 2010 Al-Nuaimi et al., 2010.	Increase in Overhead Expenses Most Contractors Incur Additional Costs Due To Variations Additional Payment For Contractor Increase in Project Cost Rework and Demolition Additional Money for Contractor Delay in Payment.	O'brien 1998, Al-Nuaimi et al., 2010, Gokulkarthi and Gowrishankar, 2015, O'Brien 1998 Gokulkarthi and Gowrishankar, 2015, Al- Nuaimi et al., 2010, Clough and Sears 1994; CII 1990a Gokulkarthi and Gowrishankar, 2015, Gokulkarthi and Gowrishankar, 2015,
Quality-Related Effects	Keane et al., 2010	Quality Degradation	CII 1994a, Fisk 1997, Gokulkarthi and Gowrishankar, 2015, Al- Nuaimi et al., 2010,
Organization and Its Reputation-Related Effects	Keane et al., 2010	Tarnish Firm's Reputation Poor Safety Conditions Poor Professional Relations Dispute Among Professionals Variations Would Result in Claims and Disputes	Fisk 1997 O'Brien 1998 Fisk 1997 Fisk 1997 Al-Nuaimi et al., 2010, ., Gokulkarthi and Gowrishankar, 2015
Performance Effects		Adversely Affect The Performance and Moral of Labor Work on Hold. Decrease in Productivity. Demolition and Rework.	Al-Nuaimi et al., 2010, . Gokulkarthi and Gowrishankar, 2015, Gokulkarthi and Gowrishankar, 2015, Gokulkarthi and Gowrishankar, 2015,
Other Effects	Keane et al., 2010	Progress Affected without Delay	CII 1994a

preconstruction period is found 1,35% while the construction period is 0,42% (Semple et al., 2018). As a case in point; length of design and implementation increase the cost of general expenses. Another effect of variation is performance, which is directly related to the quality and time of the project. Rework of the insufficient quality works also have costly consequences. The cost variations during the execution phase not only affect the financial situation of the project but also the quality level and all stakeholders' satisfaction. Contractor in terms of time and cost presents every change order to the owner for the final decision. When the costs are high for a specific change order, it prefigures the cost of other change orders (Touran, 2003b). As understood that cost impacts are the final result for every effect of the variations. By the importance of the cost for every stakeholder, variations on cost as a result of the changes are investigated in this research. It is found that the cost variations due to the change orders cause 10%-30% of contract value according to the 55,6% of the respondents in the survey (Staiti et al., 2016). Awareness of the importance of the variations leads people to study on the impacts and to search the ways of reducing the impact. Dow et al. (2009) investigated the impact of particular variables on cost variations between order values and final accounts for certain trade subcontractor.

2.3 Cost Variations in Fit-Out Construction

The seeking of the different needs spread out “fit-out” term lately in construction practices. The construction sector is a dynamic work area that many people involved in therefore all of the participants have different demands and needs from the same project. Adding a new application process into construction to meet the needs of the client is a valuable consideration (Baccarini and Bateup, 2008). The client is mostly a company that has lots of participants as users of the project. Satisfaction of the users has become one of the main concerns of the projects.

Fit-out construction is common in high-rise and multi-use buildings and vertical mutual areas that most of the works are completed in shell and core phase of the projects. Shell only or shell and core projects that provide the structure and the facade of the building including service installations or plants of the services such as HVAC in common areas are completed with fit-out works before operation of the building (BREEAM UK, 2014). Another explanation of fit-out work is that users' need for internal accommodation works to complete the building shell, services with or without

a structural envelope of a building (HM Government, 2010). As a consequence of different moving days of different users, the building services run the operation at the end of the shell and core phase, however, every user (clients for fit-out projects) needs to construct their own electrical, mechanical and architectural services according to their own design by feeding on building systems.

Fit out projects are commonly demanded by corporate firms which expect to complete planned construction or individual people who want to get expertise for their projects. Shell and core phase is completed by the main contractor and mostly their contract and working duration finish and the main contractor leave the building entirely. The tenants of the private areas to the different clients are performed after the shell and core contractor leaves. Therefore fit-out contractors are different from the main contractor of shell and core phase of the building. Each individual parts may be constructed by different fit-out contractors and designed by different designers which are chosen by each tenants. Figure 2.2 shows the participants of the shell and core and fit-out constructions and their relationships.

Fit-out approach is applicable for any kind of building because the necessities of the users are completed in the scope of fit-out works. The function of the building may be an office place, stores, a hospital or factory. As a result of the new working trends fit-out works are common for office projects lead by professional consultancies. Baccarini and Bateup (2008) described four levels in a fit-out office space design :

- (1) Building shell is structure and envelope of the building,
- (2) Building services are environmental services supplied by electromechanical works and equipment,
- (3) Scenery is interior finishing works and elements,
- (4) Settings involve furniture and equipment.

From the standpoint of these steps, it appears that all multiuser buildings include fit-out works.

Design stages and requirements for the project should be defined specifically for the fit-out projects. Buildings constructed in order to tenant to different users are completed common spaces and private spaces for the tenants are left with the structures and base services. Therefore, guides and regulations that are technical specifications

through materials to use and the design criteria for the fit-out works are dictated to the possible users. In the Office Accommodation Workspace and Fitout Standards, a guideline through the design, requirements, and application of fit-out works are described, further benchmarks are set to aid the guide budget of the tenants with two parameters that are maximum cost rate for new fit-out projects and maximum cost of fit-out per person (GOAC, 2004). Thus, work settings with the requirements are defined to design the workplace. For instance, hub spaces are called for support areas for photocopying, printing etc. that works with the meeting rooms and workstations and the guides specify the size, lighting requirements and design criteria of these areas. In the same way, guides for malls or regulations for hospitals are prepared in detail.

Fit-construction delivers advantages for saving time and cost. For the reason of the completed shell and base of the technical components, the construction speed is decreased. The performance through the schedule of the project tends to be better in fit-out projects rather than the new build projects (Love et al., 2005). The demolition until the structure for the following tenant results in less waste and more energy efficient works due to the prevention of concrete works. Furthermore, flexibility between users is implemented with less energy and cost. In addition to the different users, the needs of the current users' are supplied with the update of the furniture and workplaces. Fit out, also named as "infill", provides a changeable environment in 10-20 years without affecting the structure and core of the building considering end users' expectations (Kendall and Teicher, 2002). The expectations of the users may include fitting the latest technologies in their workplaces. These additions are requested to improve the capacity of the workplace and productivity of the employees. Lately spread out open space offices lead to other special areas such as collaboration areas to achieve team building and quiet booths in order to focus individually.

The pursuit of professionals from different organizations is to establish the cost of the standardized fit-out projects by examining the occurred project data and designing a series of cost constituent. The constituents of a cost estimation are not only direct construction expenditure, but all indirect costs such as taxes or insurance have also impact on cost. Different variables of the direct costs such as design of the project, the place of the project and choices of the materials are known with the impact on the cost however building charges for services, consultancy fees for legacy and management, organizational logistic costs and all direct costs such as insurance and

education of the users are additional expenses to consider (Oktra, 2018). As a consequence of the range of the office fit-out projects, various consultancies report the cost-based analysis based on their data to guide the owners and designers. Standard fit-out budget breakdown comprises hard costs (fit-out costs) 54,4%, design, and fees 12,3%, FF&E 20,2%, and tenant factors 13,1% of final cost among over 2.800 US and Canada projects in 2017 (JLL, 2018). In addition to US and Canada region, the rate of the fit-out costs and FF&E are calculated relatively close ratio to each other in EMEA area beside Berlin, Paris and Dublin are published as the most expensive markets by cost per square meters in 2017 (JLL, 2017). Fit-out cost index is calculated compared with London(1.00) for 23 key markets across four global regions to show the relativity of key markets around the world and New York (1.22), Frankfurt (1.21), San Francisco (1.19) have the highest three costs in 2017 (CBRE, 2018). The total value of works undertaken is £123M and total area of works undertaken is 1,141,500 sq. ft. in London and South East in 2017 only for one consultancy company (Cushman&Wakefield, 2018). The average cost for a unit area may differ with location or requests of the specification level of the design. Given statistical data for fit-out projects are the outcome of the pursuit of cost estimation for further projects. Meanwhile to the computation of unit area prices, the market inclination depending on inflation is another investigation subject in order to cost predictions. Inflation forecasts for the following years and surveys to analyse the order books through the subcontractors and suppliers show the price consistency of the works in the fit-out projects. Warm market with moderate competition is expected for acoustic paneling, carpet/flooring, and joinery works while strong competition for MEP and Ceilings/Drywall and reduced workload and intense competition for AV is expected in 2017 (Turner&Townsend, 2017). Total shell and fit-out cost for per square meters are given \$56.53 for the stores, in addition, the average prices for each work categories, flooring, ceilings, display fixtures, interior lighting, interior signage, roofing, HVAC, exterior signage, are priced (URL-1, 2013). Work breakdown is used for the forecasts of possible prices and planning considerations.

Changes in defined density increase cost in particular square meter and cost variations are expected. The percent of cost overruns that result from change orders in 22 Qatari construction projects are calculated for the civil, MEP, finishes, and design was equal to 42.90, 26.29, 25.78, and 4.28% (Senouci et al., 2017). Therefore the impact of work

items in the final cost of the fit-out projects come into question in order to ensure the accuracy of cost estimations. Changes in working practices have intensified the office fit-out projects and demand for new office places initiate different countries to compare their cost with others. This comparison should be considered with the following six advice:

- (1) The cooperation with the experts should be considered to mitigate the risk and uncertainties.
- (2) Deviation in the currency should be monitored continuously to benchmark the real market prices.
- (3) Cost inflation in the market caused by the material and labour costs should be included in the decision-making process.
- (4) Potential labour capacity of the market is an important parameter to plan the schedule and the cost.
- (5) Supply chain budget to meet the cost of the import materials should be added in the project budget.
- (6) Project delivery practices for the specified area should be considered.(JLL, 2016).

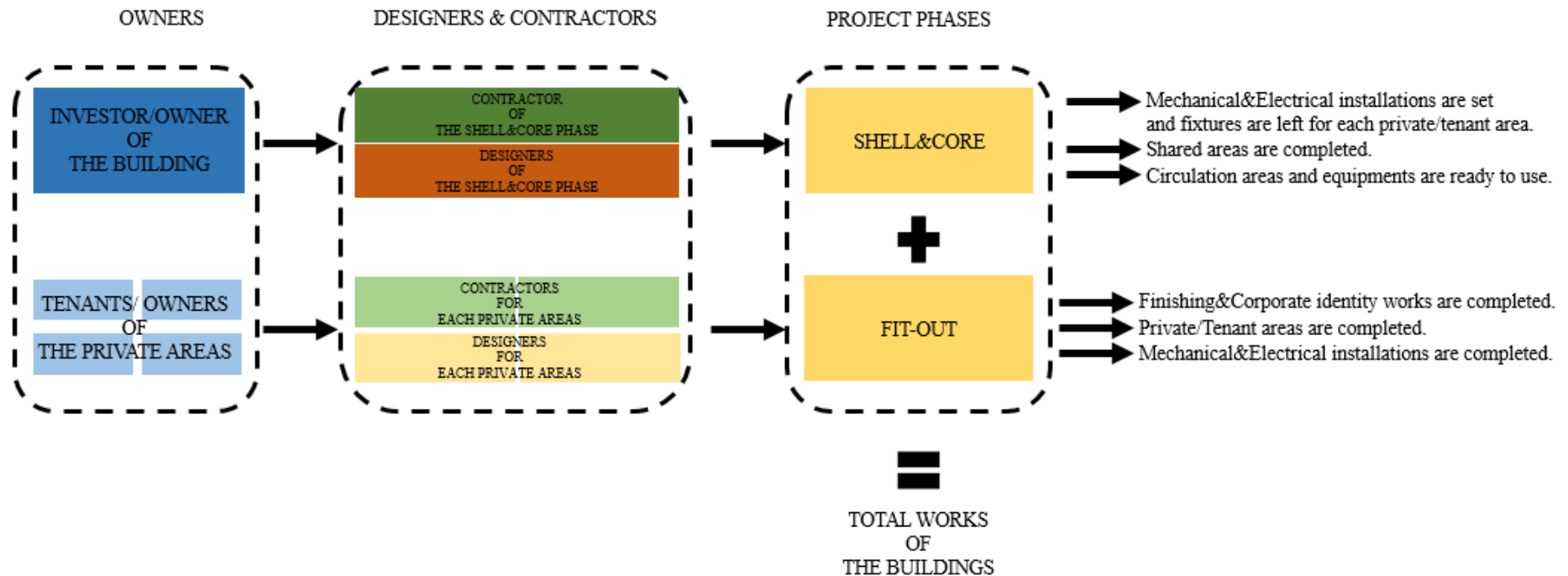


Figure 2.2 The flow chart illustrating shell&core and fit-out concept.



3. RESEARCH METHODS

The aim of the research is to identify the significant work items having cost variations in the fit-out projects (Table 1.1). Following the literature review, the cost variation intensive work items in fit-out-projects have been analysed based on case studies consisting of 10 fit-out-projects. Furthermore, detailed causes of these cost variations have been investigated in the interviews carried out with the team worked in these projects.

Projects had been obtained from a fit-out specialist company which is usually have projects in İstanbul. The company have both design and construction teams. Therefore there are design-build and bid-build projects in the company's portfolio. Brief information about 10 projects had been summarized in Table 3.1 in terms of their project delivery and payment methods.

After examining completed project data of 10 project as the case study, an interview with the project team has been decided. The interview is based on the variations between estimated cost and the actual cost in fit-out projects and the reasons behind these variations.

The following steps will be followed as in the study (Figure 3.1);

- Data collection from case studies,
- Identification of work items for each project,
- Sorting work items according to their magnitude of impact on cost,
- Defining the relation between each project results,
- Interview with the team of the projects based on results,
- Listing the possible factors behind the results with the interview.

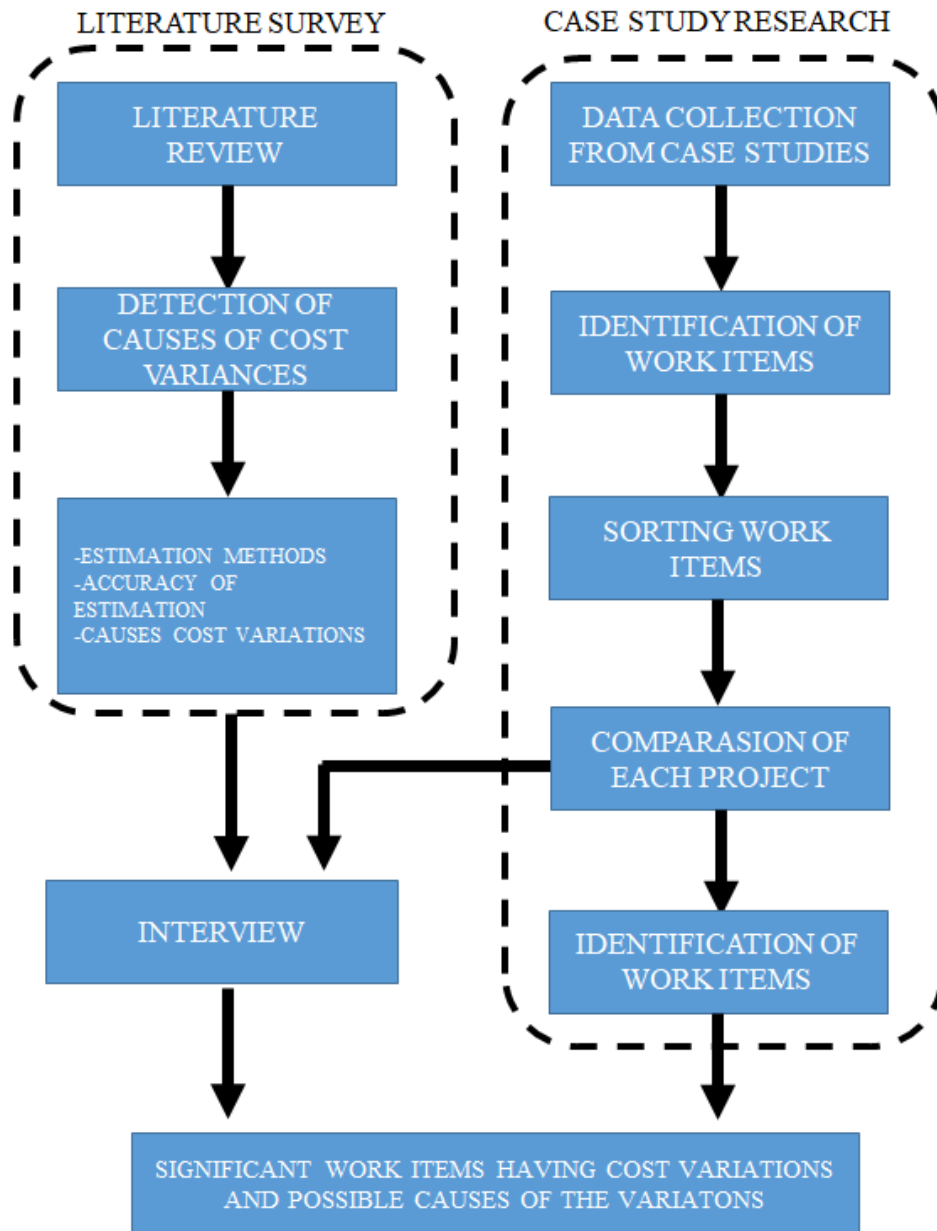


Figure 3.1 : The flow chart of the research methodology

3.1 Collection of the Project Data

The aim of the data collection process is to achieve the reliable to analyse. The projects selected were supplied from an architectural firm, which works as both designer and contractor. All ten case studies had a similar scope; fit-out projects consisted of resembling elements such as gypsum walls, carpet and LVT floorings, wood, glass, aluminum wall coverings, and furniture. Brief specialties of the case studies are:

Case Study A: A is an office project completed in 2017 for an international production company. All civil, electrical and mechanical disciplines were executed in the scope of the project. By the reason that epoxy finishing floor coats and furniture were in the client's scope, they were not included in the costs.

Case Study B: B is a restaurant project for a restaurant chain in Turkey. All civil, electrical and mechanical disciplines were executed in the scope of the project.

Case Study C: C is an office project for a Turkish legal consultant company. All civil, electrical and mechanical disciplines were executed in the scope of the project. Furniture was not included in the cost scope.

Case Study D: D is a housing project for in a luxury neighborhood. All civil, electrical and mechanical disciplines and the design were executed in the scope of the project. Furniture was purchased by the client and not included in costs.

Case Study E: E is a corporation hall entrance for Communication Company. All civil, electrical and mechanical disciplines were executed in the scope of the project.

Case Study F: F is an office project for an international health product supplier. All civil, electrical and mechanical disciplines and the design were executed in the scope of the project.

Case Study G: G is an office project for an international retailer-consumer product company. All civil, electrical and mechanical disciplines were executed in the scope of the project.

Case Study H: H is an office project for an international pharmaceutical company. All civil, electrical and mechanical disciplines were executed in the scope of the project.

Case Study I: I is a branch office project for an international bank. All civil, electrical and mechanical disciplines were executed in the scope of the project.

Table 3.1 : Brief information on the 10 projects.

Project Code	Project Type	Completion Year	Project Location	Payment Type	Project Delivery Method
Project A	Office	2017	İstanbul	Lump-sum	Bid/Build
Project B	Restaurant	2016	İstanbul	Lump-sum	Bid/Build
Project C	Office	2016	İstanbul	Cost + Fix Price	Design/Build
Project D	Housing	2016	İstanbul	Cost + Fix Price	Design/Build
Project E	Corporation Hall	2016	İstanbul	Lump-sum	Bid/Build
Project F	Office	2016	İstanbul	Cost + Fix Price	Design/Build
Project G	Office	2015	İstanbul	Cost + Fix Price	Bid/Build
Project H	Office	2015	İstanbul	Lump-sum	Bid/Build
Project I	Office	2017	Ankara	Lump-sum	Bid/Build
Project J	Office	2016	İstanbul	Lump-sum	Bid/Build

Case Study J: J is an office project completed in 2015 for an international chemical firm. All civil, electrical and mechanical disciplines were executed in the scope of the project. Furniture was included in the cost scope.

Table 3 summarizes the project information of analysed cases. in 10 of the projects, 7 leading types of projects were office projects, and the rest of the projects were 1 housing, 1 corporation hall, 1 restaurant. 3 of 10 projects were design/build projects and the rest of the projects were bid-build project delivery system. 4 of the 10 projects were paid cost plus fixed fee and 6 of the 10 projects were paid the lump sum.

3.2 Identification of the Work Items

All projects have its own specialties and work description of itself, additionally, numbers of categorization system or work breakdown are used in the planning phase of every different project. in order to analyse all projects detachedly, it is decided to use an accepted system for categorization of each work items. Master format is one of these created systems that helps planners to check all of the possible works in the project and allows every part of the projects agree on. Master Format:

A publication of CSI and CSC is a master list of numbers and titles classified by work results. It is primarily used to organize project manuals and detailed cost information and to relate drawing notations to specifications. (CSI, 2018).

Master Format is divided into 5 specifications groups: general requirements subgroup, facility construction subgroup, facility services subgroup, site, and infrastructure subgroup, process equipment subgroup. Moreover, each subgroup is divided into 50 divisions in total. Specifications group divisions are as listed below:

General Requirements Subgroup: Division 01

Facility Construction Subgroup: Divisions 02 - 19

Facility Services Subgroup: Divisions 20 - 29

Site and Infrastructure Subgroup: Divisions 30 - 39

Process Equipment Subgroup: Divisions 40 – 49

Groups are not numbered but are divided into Subgroups. Subgroups are not numbered but are divided into numbered Divisions. Divisions are the top Level (Level 1) in the hierarchy of the classification system. The Divisions include sets of numbered Titles

(Levels 2-4). in a project manual application, the Titles are called Sections that specify, "Work results" (Levels 2-4). (CSI, 2013) As seen in Table 3.2 work items of 10 selected projects are classified in Divisions. in addition, the subtitled works that are included under these categories have been added in Appendix A.1.

In order to detect variations due to changes, estimated costs, actual costs, and change orders are established in 21 divisions (Table 3.2). All estimated costs, actual costs, and change order costs were listed by the amount of each division. The impact of the changes shows the importance of the work items. To determine the significant work items on cost, they were sorted based on the percentage of each work item on the overall actual cost of the project. By sorting work, items through the percentage of the sum of actual costs the effective work items on the cost were utilized.

Table 3.2 : Master format work items.

CODE	WORK ITEMS	LEVEL
02 00	EXISTING CONDITIONS	DIVISION
03 00	CONCRETE	DIVISION
04 00	MASONRY	DIVISION
05 00	METALS	DIVISION
06 00	WOOD, PLASTICS, and COMPOSITES	DIVISION
07 00	THERMAL and MOISTURE PROTECTION	DIVISION
08 00	OPENINGS	DIVISION
09 00	FINISHES	DIVISION
10 00	SPECIALITIES	DIVISION
11 00	EQUIPMENT	DIVISION
12 00	FURNISHINGS	DIVISION
13 00	SPECIAL CONSTRUCTION	DIVISION
14 00	CONVEYING EQUIPMENT	DIVISION
21 00	FIRE SUSPENSION	DIVISION
22 00	PLUMBING	DIVISION
23 00	HVAC SYSTEMS	DIVISION
25 00	INTEGRATED AUTOMATION	DIVISION
26 00	ELECTRICAL	DIVISION
27 00	COMMUNICATION	DIVISION
28 00	ELECTRONIC SAFETY and SECURITY	DIVISION
31 00	EARTHWORK	DIVISION

3.3 Preparation of the Interview Questions

An interview methodology was adopted to support the findings through case studies and to detect the factors affecting the variations in each project. The interview was sent to 3 architects/engineers of the team. The interviewees were selected from each department of the team. Team members were from the head or authorized people in their departments. The specialties of the interviewees were presented in Table 3.3. The responses of the 3 members of the team were achieved, as well, the research describes analyses of the comparison of the architects/engineers' response and case studies. All results were examined and explained through the literature findings. All questions asked during the interview are shown in Table 3.4.

Table 3.3 : Overview of interviewees' experiences.

Code of the Person	Experience in Construction	Profession	Role in the company
Person A	10	M. Sc. Architect	Budget and contract manager
Person B	10	Civil Engineer	Site manager
Person C	26	M. Sc. Architect	The owner of the company

Table 3.4 : Overview of interview questions and interviewees.

Interview Questions	Interviewees
Please specify the details of all the projects in terms of project type, year, contractual conditions.	Person A Person C
Please list the reasons for changes and cost variations in all of the projects.	Person A Person B Person C
What are the important factors affecting the cost?	Person A Person B Person C
What are the precautions and actions you take to avoid the cost variations?	Person A Person B Person C



4. RESULTS

10 fit-out projects, which were taken as case studies have been presented and analysed in three steps. The first step includes all projects' financial data that have been analysed based on the work items. These analyses have been carried out with respect to the estimated costs, actual costs, change orders and their impacts on budget. The analyses of the 10 projects were completed with each project's spreadsheets. The second step is to combine the results of projects and to achieve a broader conclusion. The last step is the summary of the interviews.

The spreadsheets include estimated costs, actual costs, change order costs and cost variations for all work items. Estimated costs, actual costs, change order costs and cost variations were established in 21 divisions of work items. Since electrical and mechanical works were tendered to the subcontractor firms, the cost changes in these work items could not be clarified in the data obtained from the company. Therefore fire suspension, plumbing, HVAC systems, integrated automation, electrical, communication, electronic safety, and security are not included in the data. In addition to this, special construction, conveying equipment and earthwork works were not in data in consequence of the scope of the fit-out projects.

It is seen that there are both cost underrun and cost overrun completed projects in the case studies. The comparison of the facts of each project shows the importance of the specific work items. Furthermore, interviews explain the reasons behind these facts clearly.

4.1 Case Study 1: Project A

Table 4.1 presents the cost of work items of Project A. Estimated cost of Project A was 5.072.563,25 TL and the project completed on 5.169.653,49 TL. The change orders increased the estimated cost 418.878,40 TL. Although additional costs the project completed 97.090,24 TL more than estimated budget in total.

The highest value of change order was Furnishings (Division 12) with 307.697,99 TL value. Change order value of Furnishings constituted 73,46% of the total change orders. The change order and the variation value of Furnishings were correlated however it was clear that there was cost underrun in the cost of Furnishings.

Table 4.1 : Total costs of Project A based on work items.

Categories Of The Work Items	Project A			
	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	101.586,65 TL	4.862,78 TL	81.037,58 TL	- 20.549,07 TL
03 Concrete	123.957,64 TL	- 29.705,82 TL	69.480,25 TL	- 54.477,39 TL
04 Masonry	- TL	- TL	- TL	- TL
05 Metals	490.865,47 TL	29.031,33 TL	429.890,76 TL	- 60.974,71 TL
06 Wood, Plastics, and Composites	16.560,00 TL	- TL	38.000,00 TL	21.440,00 TL
07 Thermal and Moisture Protection	16.406,99 TL	2.155,79 TL	2.157,20 TL	- 14.249,79 TL
08 Openings	416.660,26 TL	47.985,43 TL	441.173,03 TL	24.512,77 TL
09 Finishes	2.040.631,90 TL	76.194,32 TL	2.144.395,54 TL	103.763,64 TL
10 Specialties	- TL	26.490,00 TL	26.490,00 TL	26.490,00 TL
11 Equipment	- TL	- TL	- TL	- TL
12 Furnishings	880.631,79 TL	307.697,99 TL	1.123.797,66 TL	243.165,87 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	- TL	- TL	- TL	- TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	129.026,36 TL	5.858,34 TL	124.142,49 TL	- 4.883,87 TL
23 Hvac Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	856.236,18 TL	- 51.691,75 TL	689.088,98 TL	- 167.147,20 TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	5.072.563,25 TL	418.878,40 TL	5.169.653,49 TL	97.090,24 TL

Figure 4.1b shows that 99,93% of the actual cost was already changed order value in Thermal and Moisture Protection (Division 07). In addition, the highest percentage of variations was the percentage of Wood, Plastics, and Composites (Figure 4.1c) however it constituted only 0,74% on total actual cost (Figure 4.1a). It is also seen Finishings (Division 09) had the highest percentage of the actual cost, however, only 3,55% of the actual cost was change order (Figure 4.1a-b). Unlike Furnishings, Specialities works (Division 10) were completely added as the change order.

Division 04, Division 11 and Division 14 had no works in the project. Furthermore, Division 06 had no change order value.

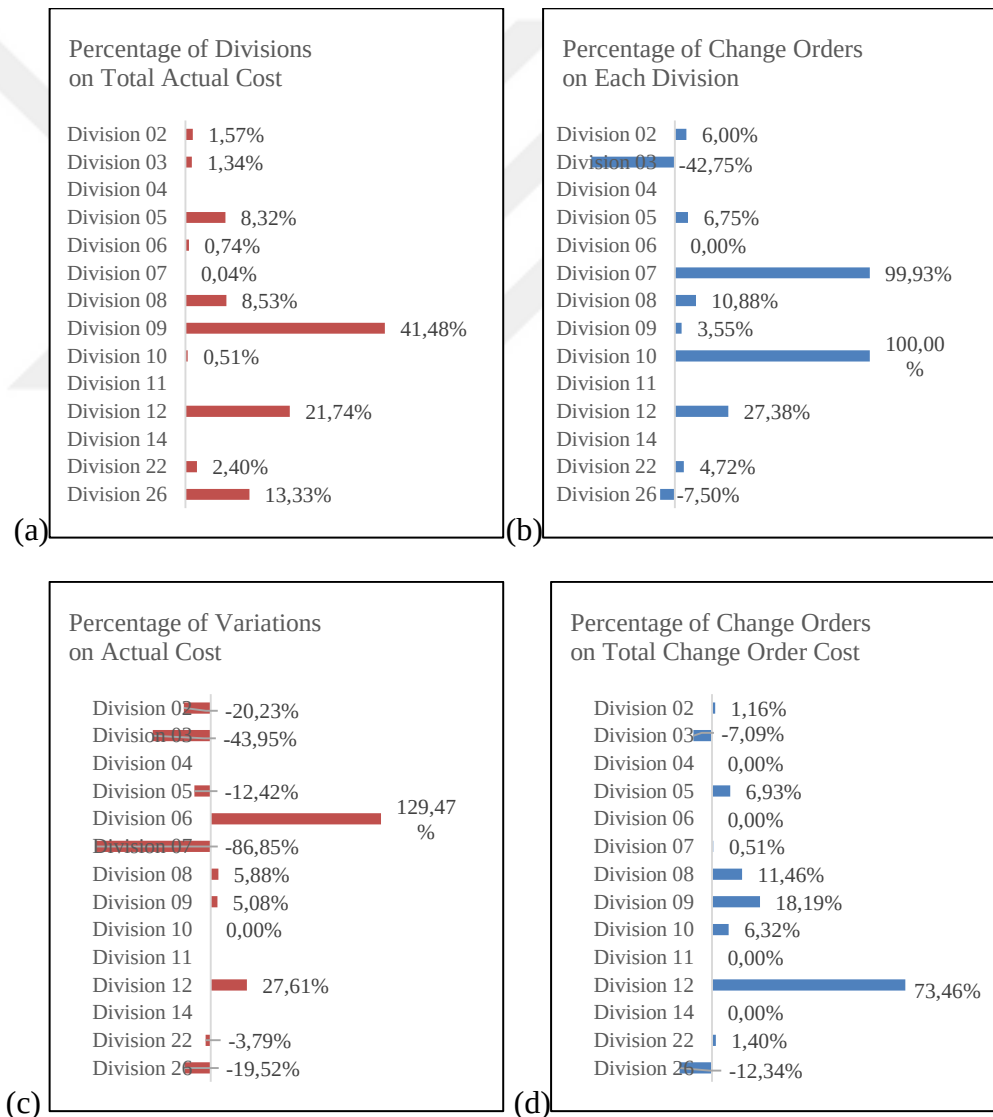


Figure 4.1 : Percentages of Project A

4.2 Case Study 2: Project B

The total estimated cost was 1.406.743,70 TL and the project was completed in 1.635.853,33 TL. Project B was completed in 229.109,63 TL variation with 14% of the actual cost (Table 4.11).

The variation value of Finishes (Division 09) was 114.931,68 and only 7,77% of actual cost of Finishes caused by change orders (Figure 4.2b). The second highest value in variation was Metals works (Division 05) with the consequence of 75.196,01 TL change order value. The change order cost and the cost variation were relatively correlated.

Table 4.2 : Total costs of Project B based on work items.

Categories Of The Work Items	Project B			
	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	56.264,00 TL	1.800,00 TL	83.721,50 TL	27.457,50 TL
03 Concrete	15.200,00 TL	- TL	23.677,00 TL	8.477,00 TL
04 Masonry	- TL	- TL	- TL	- TL
05 Metals	270.015,00 TL	75.196,01 TL	341.533,94 TL	71.518,94 TL
06 Wood, Plastics, and Composites	- TL	600,00 TL	600,00 TL	600,00 TL
07 Thermal and Moisture Protection	14.892,00 TL	2.000,00 TL	29.456,54 TL	14.564,54 TL
08 Openings	368.400,00 TL	1.135,31 TL	382.894,31 TL	14.494,31 TL
09 Finishes	400.626,71 TL	40.040,10 TL	515.558,39 TL	114.931,68 TL
10 Specialties	11.269,20 TL	7.950,00 TL	27.400,00 TL	16.130,80 TL
11 Equipment	- TL	- TL	- TL	- TL
12 Furnishings	197.171,00 TL	16.237,00 TL	161.929,06 TL	- 35.241,94 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	- TL	- TL	- TL	- TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	- TL	- TL	- TL	- TL
23 Hvac Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	72.905,79 TL	- TL	69.082,60 TL	- 3.823,19 TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	1.406.743,70 TL	144.958,42 TL	1.635.853,33 TL	229.109,63 TL

Finishes had the highest percentage of actual cost (31,52%) (Figure 4.2a). The following works were Openings (Division 05)(23,41%) and Metals (Division 05) (20,88%) in order (Figure 4.2a). The percentages of the change order for these divisions were 0,30% and 22,02%. Wood, Plastics, and Composites (Division 06) was 0,04% of the actual total cost and 100% of it was the change order. Metals had the highest percentage of change order(51,87%) (Figure 4.2d). Furnishings (Division 12) and Electrical (Division 26) completed in cost underrun although Division 12 had 10,03% change order on actual division cost.

Out of scope works were Division 04, Division 11, Division 14, Division 22 (Figure 4.1a). Electrical works had no change orders.

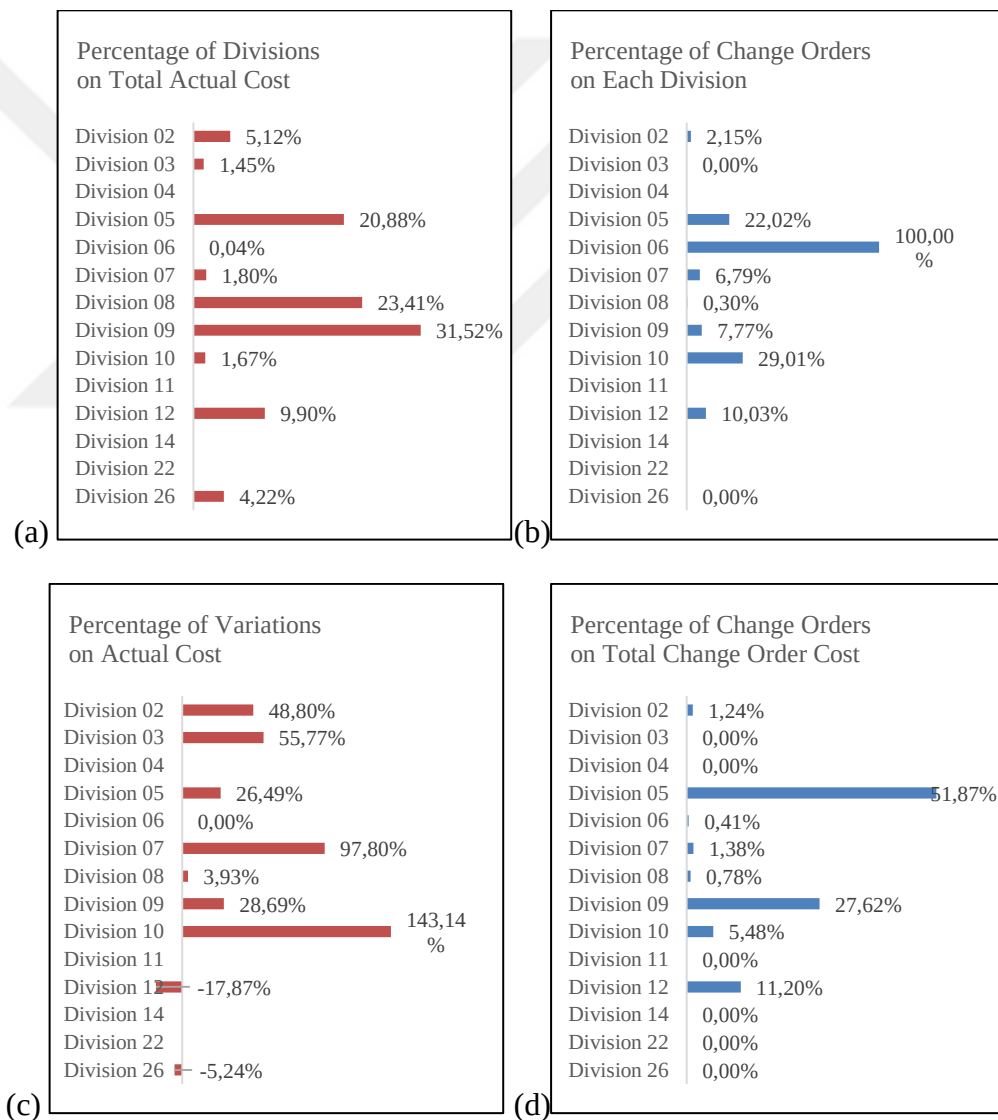


Figure 4.2 : Percentages of Project B

4.3 Case Study 3: Project C

As it is seen in Table 4.3, Project C had completed 1.539.471,07 TL that was 93.309,11 TL cost underrun from the estimated budget. Correspondingly Project A, the change orders caused 270.427,86 TL additional cost on actual cost. Work items that have the highest percentage of the actual cost had completed with the significant change order value. For instance, as the highest cost percentage of actual cost; Division 09 had 13,64% of its cost by change orders (Figure 4.3a-b). Besides, Metals (Division 05) and Openings (Division 08) had the following highest costs besides in order 14,49% and 54,79% of their cost caused by change orders (Figure 4.3 b).

Table 4.3 : Total costs of Project C based on work items.

Project C				
Categories Of The Work Items	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	23.460,00 TL	8.599,90 TL	34.114,90 TL	10.654,90 TL
03 Concrete	1.283,00 TL	- TL	772,69 TL	- 510,31 TL
04 Masonry	1.500,00 TL	- TL	153,13 TL	- 1.346,87 TL
05 Metals	417.568,54 TL	55.934,65 TL	385.942,09 TL	- 31.626,45 TL
06 Wood, Plastics, and Composites	- TL	- TL	- TL	- TL
07 Thermal and Moisture Protection	1.575,37 TL	- TL	9.715,59 TL	8.140,23 TL
08 Openings	272.735,84 TL	127.105,78 TL	232.004,71 TL	- 40.731,13 TL
09 Finishes	555.859,63 TL	69.088,78 TL	506.574,81 TL	- 49.284,82 TL
10 Specialties	1.000,00 TL	- TL	2.370,00 TL	1.370,00 TL
11 Equipment	- TL	- TL	- TL	- TL
12 Furnishings	119.262,83 TL	9.698,76 TL	134.298,49 TL	15.035,66 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	111.430,20 TL	- TL	105.392,47 TL	- 6.037,73 TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	32.261,78 TL	- TL	34.990,90 TL	2.729,12 TL
23 Hvac Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	94.843,00 TL	- TL	93.141,30 TL	- 1.701,70 TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	1.632.780,18 TL	270.427,86 TL	1.539.471,07 TL	- 93.309,11 TL

Although Existing Conditions had 26,21% of its actual cost, The percentage of the division was 2,22% (Figure 4.3b-a). On the other hand, Thermal and Moisture Protection (Division 07) had the major variation percentage (516,72%). The total cost of this difference was only 0,63% of the total actual cost with 8.140,23 TL (Figure 4.3c).

The changes in the project occurred in Division 02, Division 05, Division 08, Division 09, Division 12 (Figure 4.3b). Division 06 and Division 11 were out of scope.

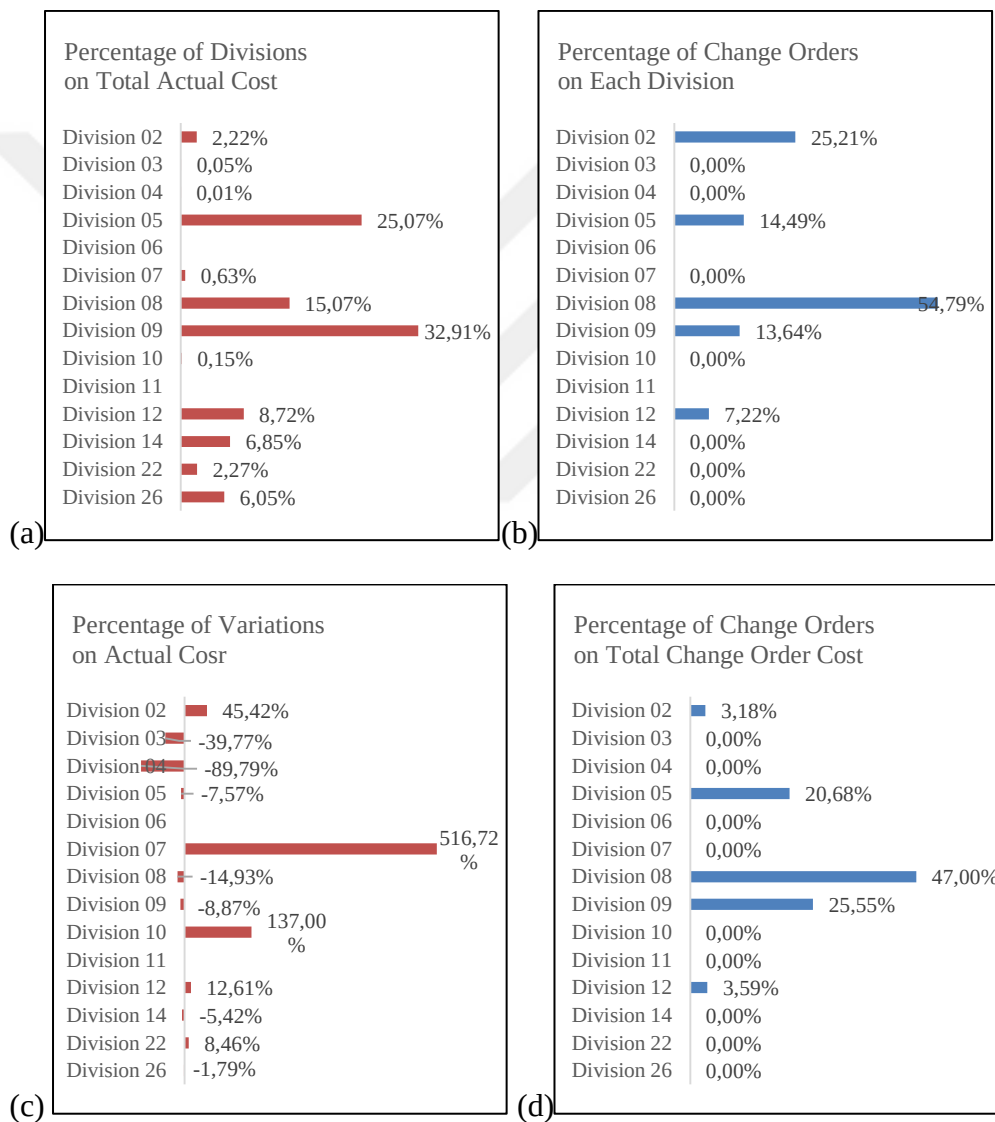


Figure 4.3 : Percentages of Project C

4.4 Case Study 4: Project D

Project D was completed with the cost overrun and 277.192,60 TL the estimated cost (Table 4.4). Total estimated cost increased from 933.187,68 TL to 1.210.380,28 TL. 385.635,38 TL of the actual cost caused by change orders.

The highest part of the changes were Concrete works (Division 03) with 194.619,09 TL. Correspondingly to the changes, the highest value of the variations was Concrete works with 177.664,25 TL cost overrun. Contrary to Concrete, Existing Conditions (Division 02) resulted in 82.708,00 TL cost underrun (-93,59) (Table 4.4).

Table 4.4 : Total costs of Project D based on work items.

Project D				
Categories Of The Work Items	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	171.080,00 TL	8.251,35 TL	88.372,00 TL	- 82.708,00 TL
03 Concrete	80.550,00 TL	194.619,09 TL	258.214,25 TL	177.664,25 TL
04 Masonry	7.200,00 TL	- TL	8.640,00 TL	1.440,00 TL
05 Metals	18.250,00 TL	39.096,80 TL	54.346,93 TL	36.096,93 TL
06 Wood, Plastics, and Composites	- TL	- TL	- TL	- TL
07 Thermal and Moisture Protection	41.400,00 TL	- TL	36.514,14 TL	- 4.885,86 TL
08 Openings	140.145,92 TL	12.935,80 TL	120.233,16 TL	- 19.912,76 TL
09 Finishes	287.188,20 TL	56.474,03 TL	364.067,88 TL	76.879,68 TL
10 Specialties	- TL	19.900,00 TL	19.900,00 TL	19.900,00 TL
11 Equipment	- TL	- TL	- TL	- TL
12 Furnishings	138.452,60 TL	49.019,34 TL	202.879,12 TL	64.426,52 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	- TL	- TL	- TL	- TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	48.920,96 TL	5.338,98 TL	57.212,82 TL	8.291,86 TL
23 Hvac Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	- TL	- TL	- TL	- TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	933.187,68 TL	385.635,38 TL	1.210.380,28 TL	277.192,60 TL

Specialties (Division 10) added completely as change order (100%) (Figure 4.4b). More than 70% of Concrete (Division 03) and Metals (Division 05) actual costs were results in change order (Figure 4.4b). As a result of their percentages on total actual cost, the impact of the changes was different. Rest of the change orders were between 9% and 25% of each division and minimum variation was 11, 8% (Figure 4.4c). Thermal and Moisture Protection (Division 07) had no change order, however, 13,38% cost underrun had been seen. Division 06, Division 11, Division 14 and Division 26 were not included in scope (Figure 4.4a).

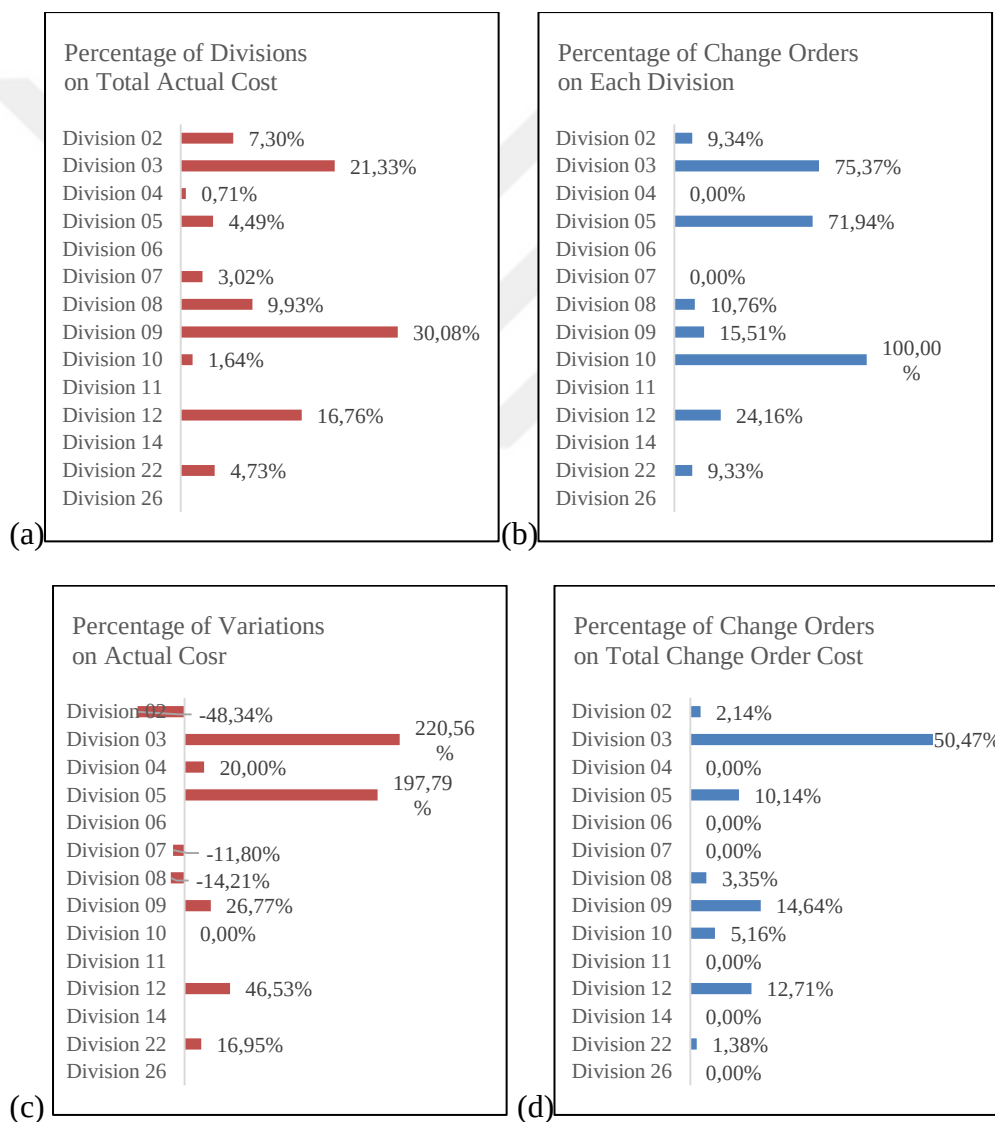


Figure 4.4 : Percentages of Project D

4.5 Case Study 5: Project E

Project E the second lowest cost between 10 case studies was completed 188.615,19 TL (Table 4.11). The change order increased the estimated cost 21.820,93 TL more while the total rise of the project was 33.622,17 TL (Table 4.5).

Except for Wood, Plastic, and Composites (Division 06) and Masonry (Division 04), all of the work divisions had raised. The highest variation cost occurred in Electrical works (Division 02) with 9.597,24 TL. The highest change order cost occurred in Finishes works (Division 09) with 8.746,34 TL.

Table 4.5 : Total costs of Project E based on work items.

Project E				
Categories Of The Work Items	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	7.290,91 TL	1.925,00 TL	14.576,95 TL	7.286,04 TL
03 Concrete	1.575,00 TL	4.973,88 TL	6.674,60 TL	5.099,60 TL
04 Masonry	1.522,10 TL	- TL	400,00 TL	- 1.122,10 TL
05 Metals	2.618,23 TL	1.745,00 TL	3.329,60 TL	711,37 TL
06 Wood, Plastics, and Composites	2.327,65 TL	350,00 TL	1.144,70 TL	- 1.182,95 TL
07 Thermal and Moisture Protection	- TL	- TL	- TL	- TL
08 Openings	6.104,55 TL	235,00 TL	9.535,00 TL	3.430,45 TL
09 Finishes	44.423,69 TL	8.746,34 TL	51.750,93 TL	7.327,24 TL
10 Specialties	- TL	- TL	- TL	- TL
11 Equipment	25.627,65 TL	338,96 TL	25.795,88 TL	168,23 TL
12 Furnishings	48.870,75 TL	- TL	50.904,48 TL	2.033,72 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	- TL	- TL	- TL	- TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	- TL	- TL	273,31 TL	273,31 TL
23 Hvac Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	14.632,49 TL	3.506,75 TL	24.229,73 TL	9.597,24 TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	154.993,01 TL	21.820,93 TL	188.615,19 TL	33.622,17 TL

Finishes (Division 09) and Furnishings (Division 12) had the highest costs in all work items (Figure 4.5a). Although Concrete (Division 03) and Metals (Division 05) had the highest the percentage of change orders in divisions, the actual cost of the divisions were less than 4% (Figure 4.5b-a). Furnishings, the second highest work item, had no change order and the variation of the division was 4%. The plumbing work (Division 22) had no cost in estimated cost however it existed in actual cost hence the variation was 100% and the change order was 0%.

Division 07, Division 10, Division 14 did not included into scope.

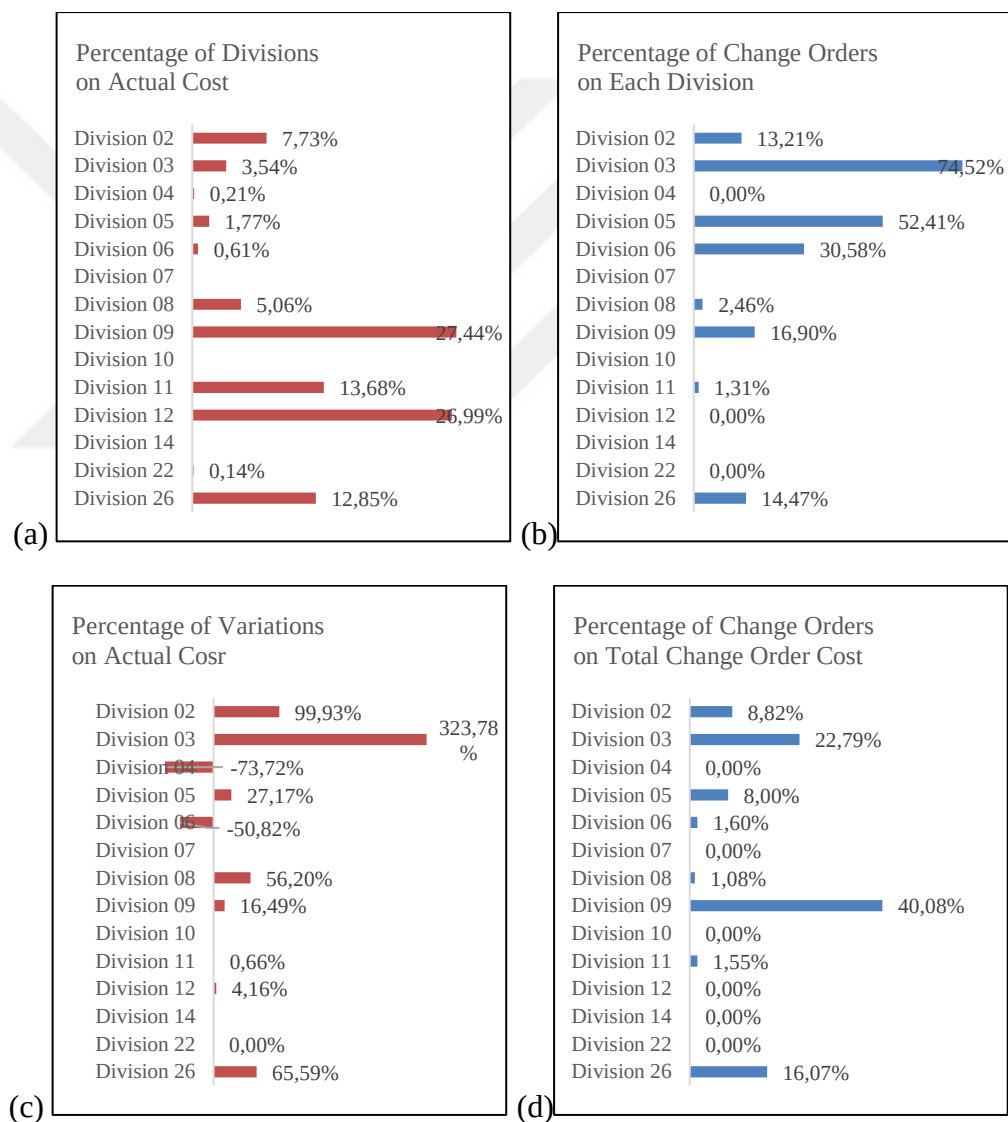


Figure 4.5 : Percentages of Project E

4.6 Case Study 6: Project F

The actual cost of Project F was 1.104.807,45 TL (Table 4.6). Project F had one of the lowest percentages of change order cost (3,5%) (Table 4.11). Total change order cost was 38.628,31 TL. Based on actual cost. 5 of the 11 work items in scope was affected by change orders. (Table 4.6). Work items responsible for these changes were; Existing Conditions, Finishes, Specialties, Furnishings, Plumbing (Divisions: 02, 09, 10, 12, 22). On the other hand, the project was completed 83.115,54 TL cost overrun in total due to the changes in other work items. The highest variation cost occurred in Finishes in behalf of change orders and other changes (Table 4.6)

Table 4.6 : Total costs of Project F based on work items.

Project F				
Categories Of The Work Items	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	15.000,00 TL	1.600,00 TL	39.709,82 TL	24.709,82 TL
03 Concrete	7.509,54 TL	- TL	7.599,90 TL	90,36 TL
04 Masonry	2.994,56 TL	- TL	3.030,60 TL	36,03 TL
05 Metals	7.681,82 TL	- TL	15.871,54 TL	8.189,73 TL
06 Wood, Plastics, and Composites	- TL	- TL	- TL	- TL
07 Thermal And Moisture Protection	3.307,41 TL	- TL	3.347,20 TL	39,80 TL
08 Openings	145.088,45 TL	- TL	155.356,28 TL	10.267,83 TL
09 Finishes	391.249,10 TL	15.179,26 TL	428.271,78 TL	37.022,68 TL
10 Specialties	- TL	10.500,00 TL	10.500,00 TL	10.500,00 TL
11 Equipment	- TL	- TL	- TL	- TL
12 Furnishings	343.861,04 TL	11.209,09 TL	348.297,24 TL	4.436,20 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	- TL	- TL	- TL	- TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	20.000,00 TL	139,96 TL	23.578,98 TL	3.578,98 TL
23 HVAC Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	85.000,00 TL	- TL	69.244,12 TL	- 15.755,88 TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	1.021.691,91 TL	38.628,31 TL	1.104.807,45 TL	83.115,54 TL

Specialties (Division 10) was added in scope during the construction (Figure 4.6b). All of the other change orders had less than 5% on the actual cost of each division (Figure 4.6b). The highest percentage of variation was Division 02, the following two divisions were: Metals (Division 05) (106,61%) and Plumbings (Division 22) (17,89%) and Electrical works (Division 26) (18,54%) (Figure 4.6c). Electrical works (Division 26) was the only cost underrun among all work items. 39,3% of all change order cost resulted from Finishes (Division 09) (Figure 4.6d) Furnishings and Specialties followed it with 29,02% and 27,18% (Figure 4.6d).

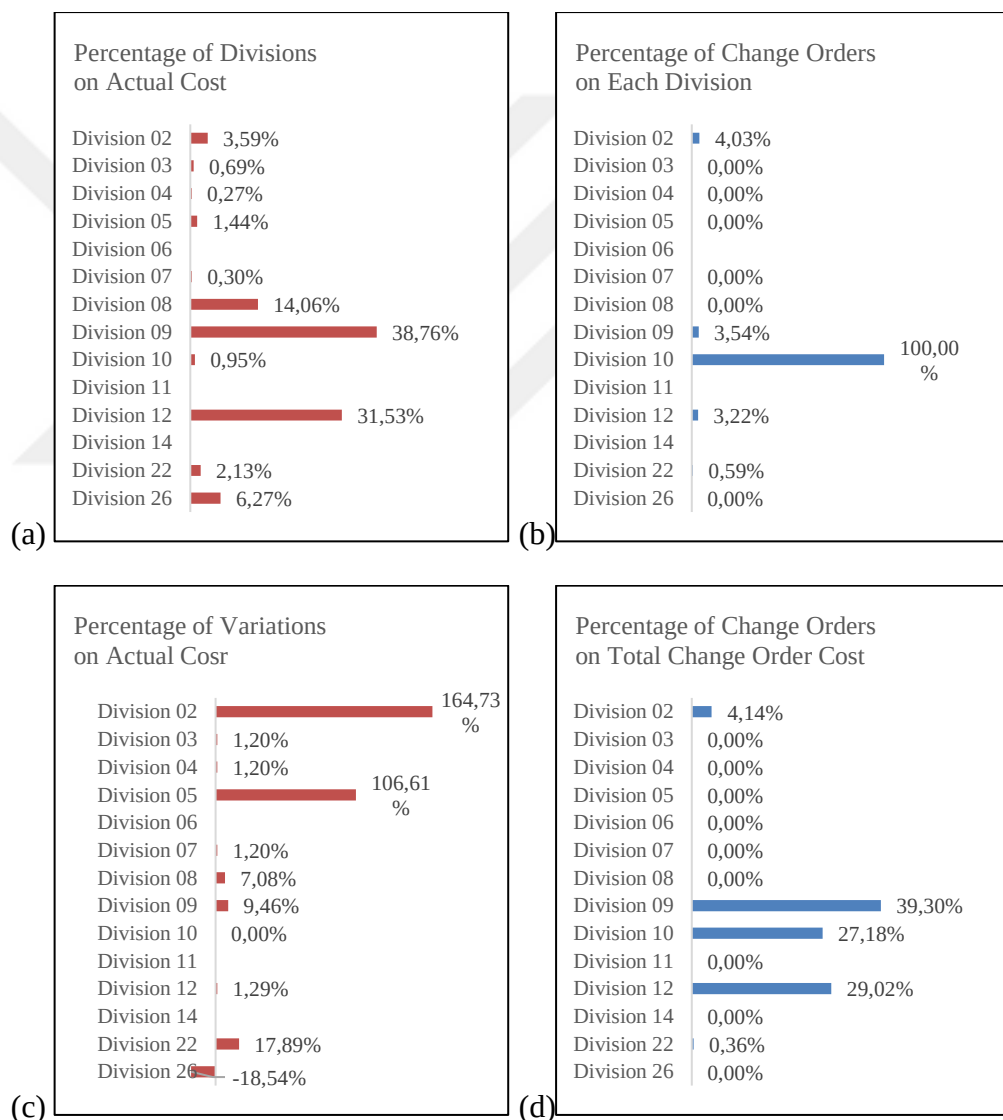


Figure 4.6 : Percentages of Project F

4.7 Case Study 7: Project G

Table 4.11 presents that Project G had the lowest variation cost but the second highest change order cost. The total value of change orders was 91.138,46 TL in actual cost, however, the variation between estimated cost and actual cost completed only 703.70 TL. The estimated cost increased from 325.915,25 TL to 326.618,95 TL (Table 4.7) Opening and Furnishings were more than 20% percentage of the actual cost (Figure 4.7a).

Table 4.7 : Total costs of Project G based on work items.

Project G				
Categories Of The Work Items	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	10.825,00 TL	19.250,00 TL	33.369,00 TL	22.544,00 TL
03 Concrete	500,00 TL	- TL	500,00 TL	- TL
04 Masonry	900,00 TL	- TL	900,00 TL	- TL
05 Metals	20.450,00 TL	754,91 TL	16.484,91 TL	- 3.965,09 TL
06 Wood, Plastics, and Composites	1.725,50 TL	- TL	1.741,00 TL	15,50 TL
07 Thermal and Moisture Protection	- TL	- TL	- TL	- TL
08 Openings	119.036,21 TL	7.043,13 TL	72.123,04 TL	- 46.913,17 TL
09 Finishes	134.423,95 TL	15.188,16 TL	123.917,24 TL	- 10.506,71 TL
10 Specialties	- TL	- TL	- TL	- TL
11 Equipment	- TL	- TL	- TL	- TL
12 Furnishings	27.690,00 TL	46.472,25 TL	67.222,25 TL	39.532,25 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	- TL	- TL	- TL	- TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	10.364,59 TL	2.430,00 TL	10.361,51 TL	- 3,08 TL
23 Hvac Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	- TL	- TL	- TL	- TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	325.915,25 TL	91.138,46 TL	326.618,95 TL	703,70 TL

The highest two work divisions were Finishes and Furnishings (Divisions 09,12) (27,44% and 26,99%) (Figure 4.7a). Both Existing Conditions and Furnishing cost caused by change orders more than their 50% cost (Figure 4.7b). Finishes, the highest cost among the work items, had 12,26% change orders of its actual cost. Openings (Division 08) had 39,41% cost underrun. On contrary to Division 08, Division 02 and Division 12 completed with cost overruns (Figure 4.7c). Furnishings had 50,99% of the total change order cost.

Division 07, Division 10 and Division 14 were not in the scope. Furthermore, Division 03, Division 04, Division 06, Division 11 and Division 26 had no change order.

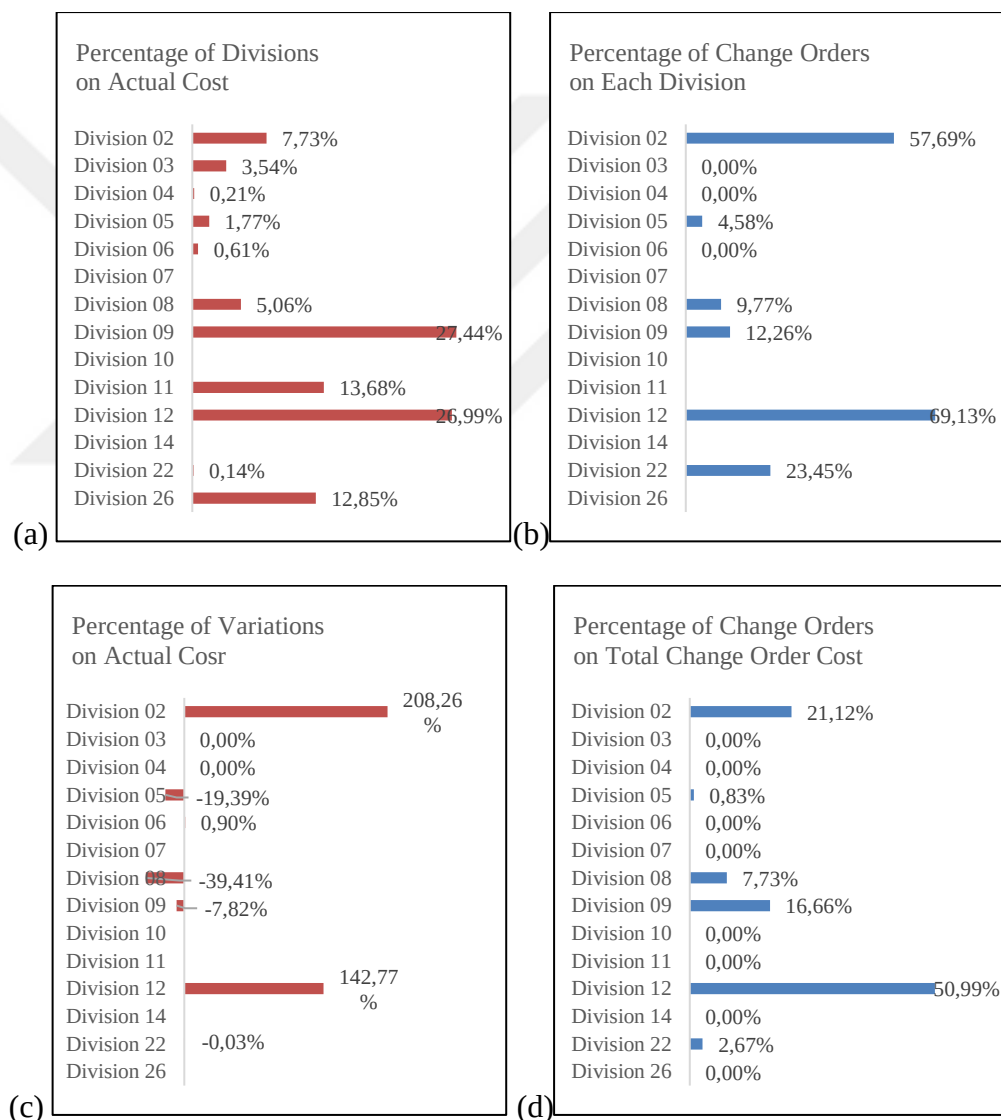


Figure 4.7 : Percentages of Project G

4.8 Case Study 8: Project H

Project H had the second lowest percentage (2,6%) of variations in actual cost between 10 case studies (Table 4.11). Likewise, the total variation in actual cost, the total change order rate is the lowest percentage (1,8%) (Table 4.11). As it is shown in Table 4.8, the total cost variation was 26.928,04 TL and 18.531,58 TL of these changes caused by change orders.

Although the change order rate is 0,72 %, the highest percentage of actual cost work item was Furnishings (Division 12)(47,62%) (Figure 4.8b-a).

Table 4.8 : Total costs of Project H based on work items.

Project H				
Categories Of The Work Items	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	12.450,80 TL	- TL	14.556,80 TL	2.106,00 TL
03 Concrete	6.030,45 TL	- TL	945,56 TL	- 5.084,88 TL
04 Masonry	- TL	- TL	- TL	- TL
05 Metals	5.837,62 TL	- TL	5.837,62 TL	- TL
06 Wood, Plastics, and Composites	- TL	- TL	- TL	- TL
07 Thermal and Moisture Protection	- TL	2.871,74 TL	2.871,74 TL	2.871,74 TL
08 Openings	124.833,40 TL	360,00 TL	126.052,71 TL	1.219,30 TL
09 Finishes	353.192,86 TL	11.100,85 TL	361.682,11 TL	8.489,25 TL
10 Specialties	11.120,66 TL	- TL	11.120,66 TL	- TL
11 Equipment	- TL	- TL	- TL	- TL
12 Furnishings	477.552,07 TL	3.539,00 TL	492.881,66 TL	15.329,59 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	- TL	- TL	- TL	- TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	17.107,24 TL	660,00 TL	19.104,28 TL	1.997,05 TL
23 Hvac Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	- TL	- TL	- TL	- TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	1.008.125,10 TL	18.531,58 TL	1.035.053,14 TL	26.928,04 TL

Finishes (Division 09) had 59,9% of all change order cost however, it constituted 3,07% of total Finishing cost (Figure 4.8d-b). Unlikely, Thermal and Moisture Protection was completely added during the construction (100%) (Figure 4.8b). Other work items had less than 4% (Figure 4.8b). The highest percentage of the actual cost was Furnishings (Division 12) with 47,62% (Figure 4.8a). Although Division 03 changed 87,32% of the estimated cost, it was 0,09% of the total actual cost (Figure 4.8c-a).

Division 04, Division 06, Division 11, Division 14, Division 26 were out of scope.

Division 05, Division 10 had no change order cost.

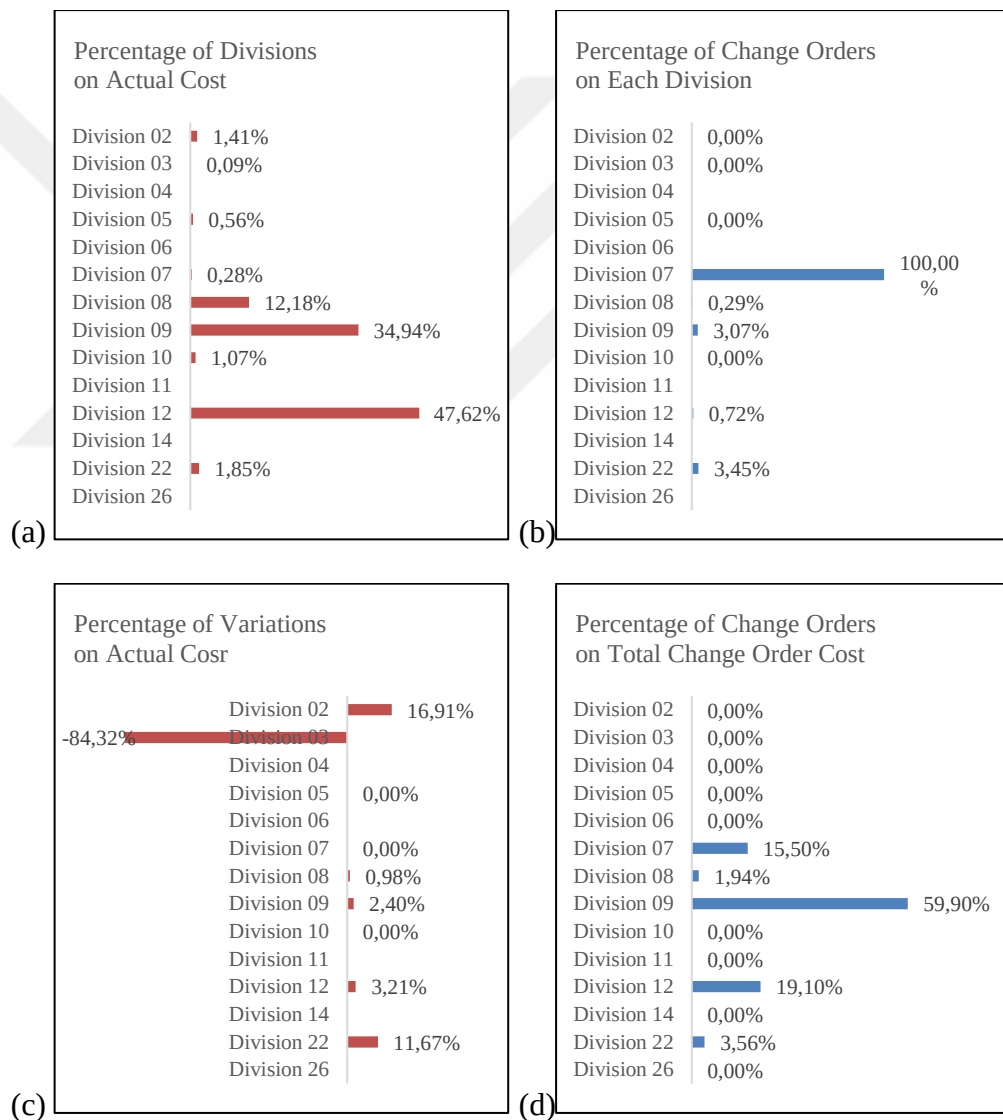


Figure 4.8 : Percentages of Project H

4.9 Case Study 9: Project I

The lowest amount of actual cost was Project I as seen in Table 4.11 due to the decrease in the estimated cost. Unlikely other cases the decrease of Project I was more than its actual cost (Table 4.9). The actual cost was completed 58.464,00 TL however, estimated cost was 118.106,90 TL (Table 4.9).

The highest decrease value accrued in Openings and Finishes (Division 08 and 09). While Finishes were increased the actual cost by change orders, the change orders decreased Openings cost in actual cost (Table 4.9).

Table 4.9 : Total costs of Project I based on work items.

Categories Of The Work Items	Project I				
	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost	
02 Existing Conditions	17.134,24 TL	1.314,75 TL	8.251,11 TL	-	8.883,13 TL
03 Concrete	320,00 TL	- 156,99 TL	163,01 TL	-	156,99 TL
04 Masonry	- TL	2.309,25 TL	500,00 TL		500,00 TL
05 Metals	7.763,39 TL	- 5.173,68 TL	1.899,93 TL	-	5.863,46 TL
06 Wood, Plastics, and Composites	- TL	- TL	- TL	-	- TL
07 Thermal and Moisture Protection	- TL	- TL	- TL	-	- TL
08 Openings	30.844,05 TL	- 3.908,70 TL	18.846,40 TL	-	11.997,65 TL
09 Finishes	45.597,93 TL	6.523,28 TL	22.168,45 TL	-	23.429,47 TL
10 Specialties	5.941,71 TL	- 3.133,46 TL	387,00 TL	-	5.554,71 TL
11 Equipment	- TL	- TL	- TL	-	- TL
12 Furnishings	10.505,57 TL	626,86 TL	6.248,10 TL	-	4.257,47 TL
13 Special Construction	- TL	- TL	- TL	-	- TL
14 Conveying Equipment	- TL	- TL	- TL	-	- TL
21 Fire Suspension	- TL	- TL	- TL	-	- TL
22 Plumbing	- TL	- TL	- TL	-	- TL
23 Hvac Systems	- TL	- TL	- TL	-	- TL
25 Integrated Automation	- TL	- TL	- TL	-	- TL
26 Electrical	- TL	- TL	- TL	-	- TL
27 Communication	- TL	- TL	- TL	-	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	-	- TL
31 Earthwork	- TL	- TL	- TL	-	- TL
Total	118.106,90 TL	- 1.598,69 TL	58.464,00 TL	-	59.642,89 TL

Change order percentages for each division were dramatic. The highest two work items; 32,24% of actual cost as Openings (Division 08) and 37,92% of actual cost as Finishes (Division 09) (Figure 4.9a). In Specialties (Division 10), the gigantic percentage in change order with 809,68% caused by minority amount of the work item in actual cost (Figure 4.9b, Table 4.9).

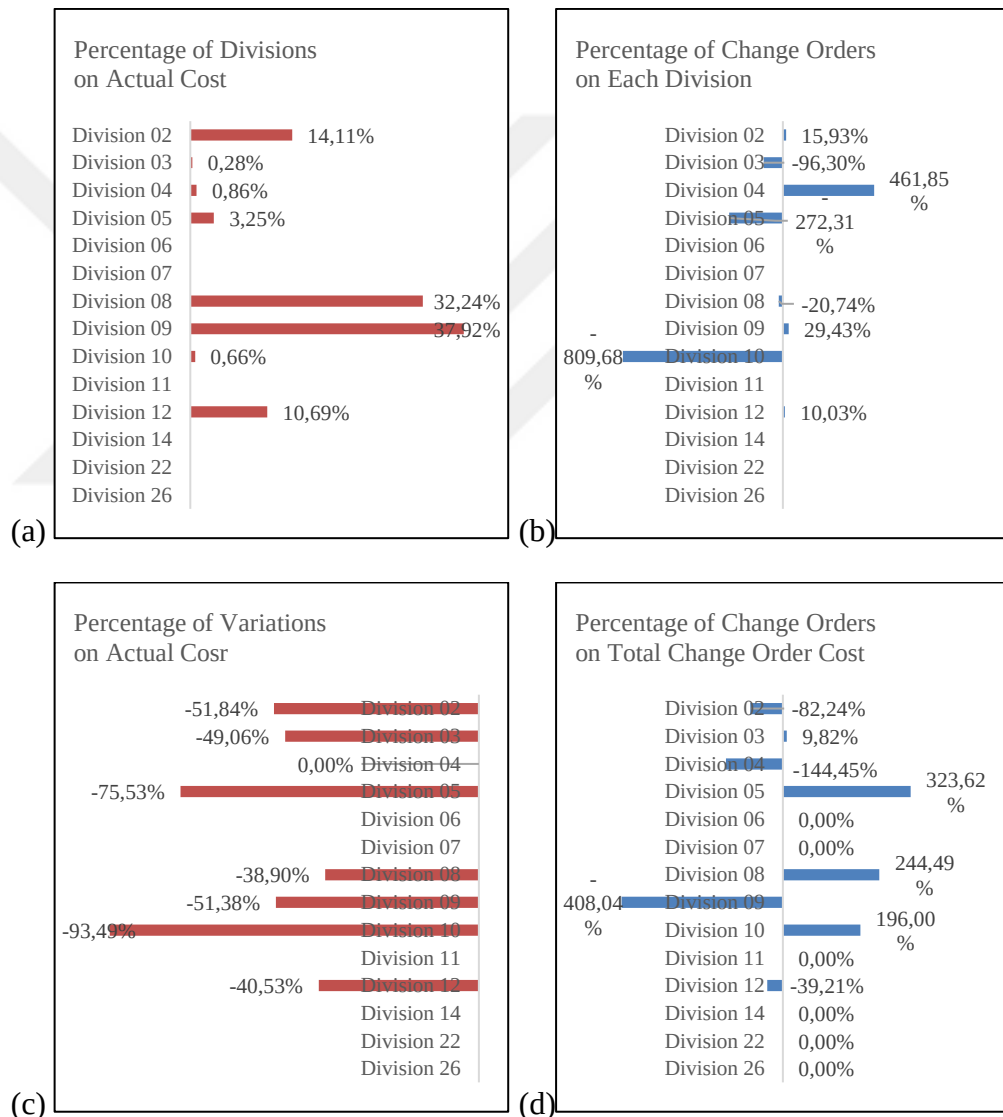


Figure 4.9 : Percentages of Project I

4.10 Case Study 10: Project J

Project J was completed 3.319.637,39 TL actual cost, and the total variation increment was 23.965,45 TL. Conversely, the change orders increased cost 186.441,23 TL (Table 4.10).

Furnishings (Division 12) and Openings (Division 09) were the highest cost variation in order; -302.419,26 TL and -158.047,98 TL. Furnishings decreased -265.629,26 TL and openings decreased -29.007,98 TL due to the change orders. Finishes (Division 09) and Equipment (Division 11) had also highest cost overruns (Table 4.10).

Table 4.10 : Total costs of Project J based on work items.

Project J				
Categories Of The Work Items	Estimated Cost	Change Order Cost	Actual Cost	Variation Cost
02 Existing Conditions	- TL	115.505,00 TL	115.505,00 TL	115.505,00 TL
03 Concrete	42.782,53 TL	9.402,25 TL	62.500,13 TL	19.717,60 TL
04 Masonry	19.102,50 TL	-17.979,70 TL	1.122,80 TL	-17.979,70 TL
05 Metals	104.002,50 TL	-2.620,50 TL	97.422,00 TL	-6.580,50 TL
06 Wood, Plastics, and Composites	- TL	- TL	- TL	- TL
07 Thermal and Moisture Protection	128.139,57 TL	11.986,75 TL	103.381,60 TL	-24.757,97 TL
08 Openings	512.909,20 TL	-29.007,98 TL	354.861,22 TL	-158.047,98 TL
09 Finishes	1.100.281,05 TL	150.693,66 TL	1.294.815,84 TL	194.534,79 TL
10 Specialties	- TL	49.349,50 TL	49.349,50 TL	49.349,50 TL
11 Equipment	- TL	152.275,24 TL	152.275,24 TL	152.275,24 TL
12 Furnishings	1.358.400,00 TL	-265.629,26 TL	1.055.980,74 TL	-302.419,26 TL
13 Special Construction	- TL	- TL	- TL	- TL
14 Conveying Equipment	- TL	- TL	- TL	- TL
21 Fire Suspension	- TL	- TL	- TL	- TL
22 Plumbing	30.054,60 TL	8.075,52 TL	28.032,58 TL	-2.022,02 TL
23 Hvac Systems	- TL	- TL	- TL	- TL
25 Integrated Automation	- TL	- TL	- TL	- TL
26 Electrical	- TL	4.390,75 TL	4.390,75 TL	4.390,75 TL
27 Communication	- TL	- TL	- TL	- TL
28 Electronic Safety and Security	- TL	- TL	- TL	- TL
31 Earthwork	- TL	- TL	- TL	- TL
Total	3.295.671,94 TL	186.441,23 TL	3.319.637,39 TL	23.965,45 TL

Existing conditions, Specialties, Equipment and Electrical works (Division 02,10, 11,26) included during the construction (100%) (Figure 4.10b). Masonry was completed with 1601,32% decrease due to change orders (Figure 4.10b) in addition percentage of the variation was 94,12% different from the estimated cost (Figure 4.10c). The work items (Division 08 and Division 09) which had the highest percentages on actual cost, were changed -8,17% and 11,64% from each work items' actual cost (Figure 4.10a-b).

Division 06, Division 07, Division 11, Division 14, Division 22 and Division 26 had no actual costs in the project.

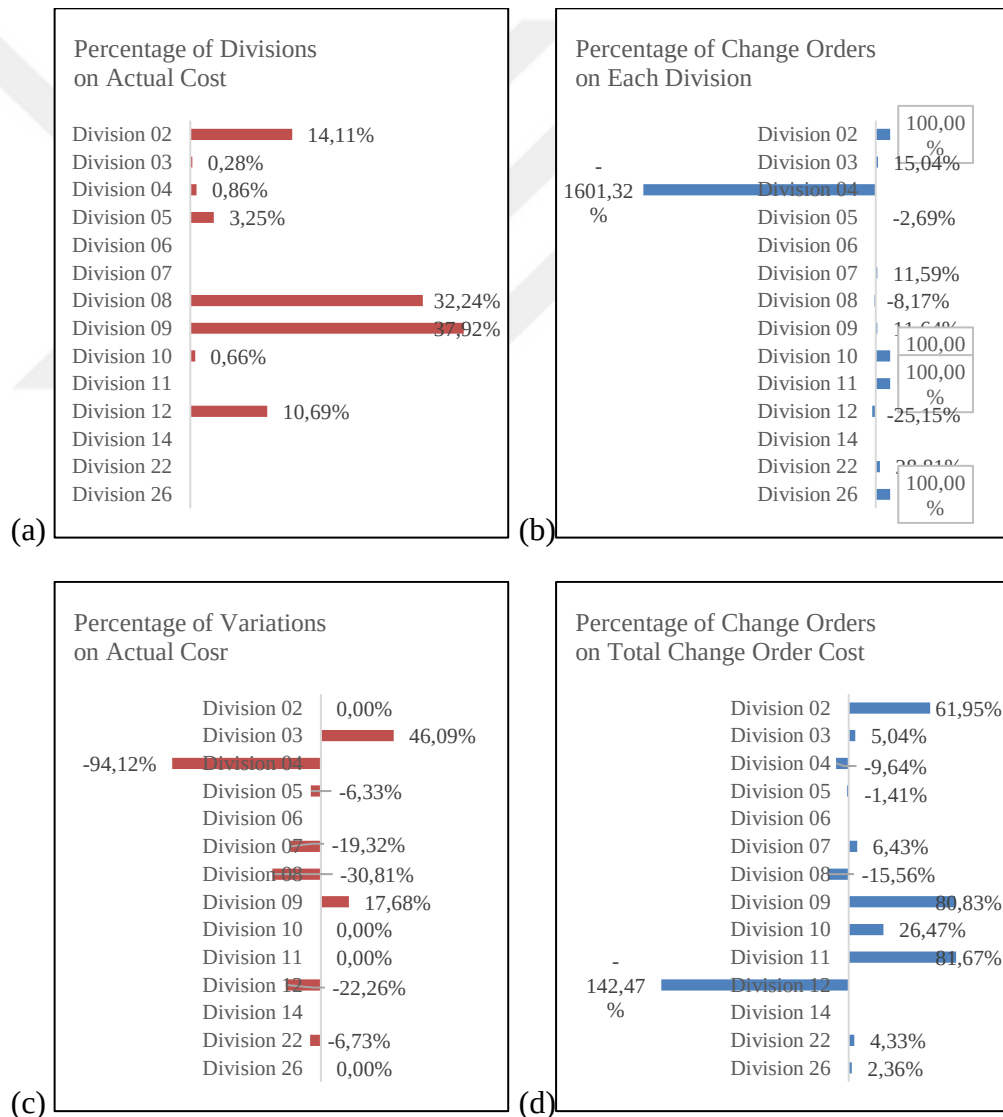


Figure 4.10 : Percentages of Project J

4.11 Comparative Analysis of the Case Studies

Figure 4.11 shows that four of the projects were completed with cost overruns and six of the projects were completed with cost underruns. The actual cost of the projects affected by the causes mentioned in Section 2, however, it is seen in Figure 4.11 that change orders and variations were not affected as aligned. As "Project A" was completed 97.090,24 TL cost underrun, the actual cost was increased in 418.878,40 TL due to change orders. This consequence shows that even if the cost was increased by change orders, the other causes affect the actual cost decreased more than change orders, which might be caused by the deal with the subcontractor, for instance. In contrast, "Project D" was completed 277.192,60 TL cost overrun and 385.635,38 TL of the actual cost was change orders. Although projects had both cost overruns and change orders, the rank of cost variations and change order costs were changeable. If Project F and Project G are compared, amount of variation of Project F is higher than the amount of change order. on the other hand, amount of change order is higher than the amount of variation in Project G (Figure 4.11).

Change orders increased or decreased the estimated cost besides other changes were also seen on actual cost. Changes affecting the secondary variation were unexpected events or were not included in change order documents. The bar charts in Figure 4.12 were illustrated through the sum of estimated cost and additional change order cost. The value of the actual cost was shown with the green point. Thus, the impact of the secondary variations was shown. Cost performance is defined as successful or failure whether or not actual cost achieved and fit into the estimated cost. For instance, it was expected that actual cost of Project B was shown on the bar chart as it was in Project A or Project C. Consequently it was stated that Project B was not completed in expected cost. The reasons behind these changes were questioned in interviews with the project team. Cost underrun of Project C was clearly seen in Figure 4.12. Despite the change orders, the actual cost was lower than the estimated cost. In addition, the actual cost of Project D was under the expected budget however it was seen the change orders affected the cost of the project.

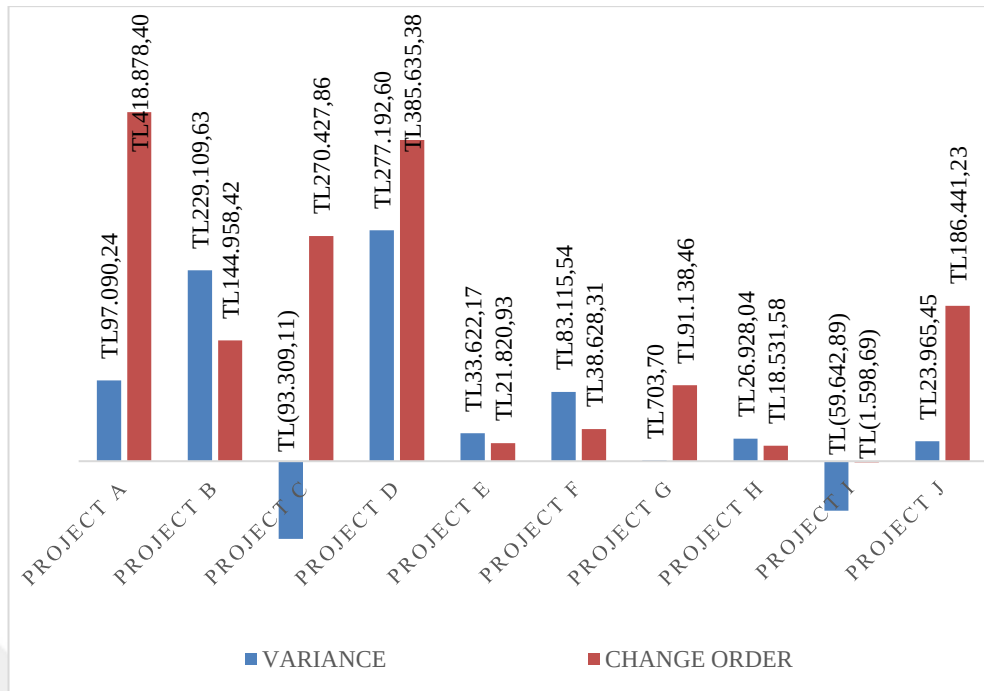


Figure 4.11 : Total variation and change order values for 10 projects.

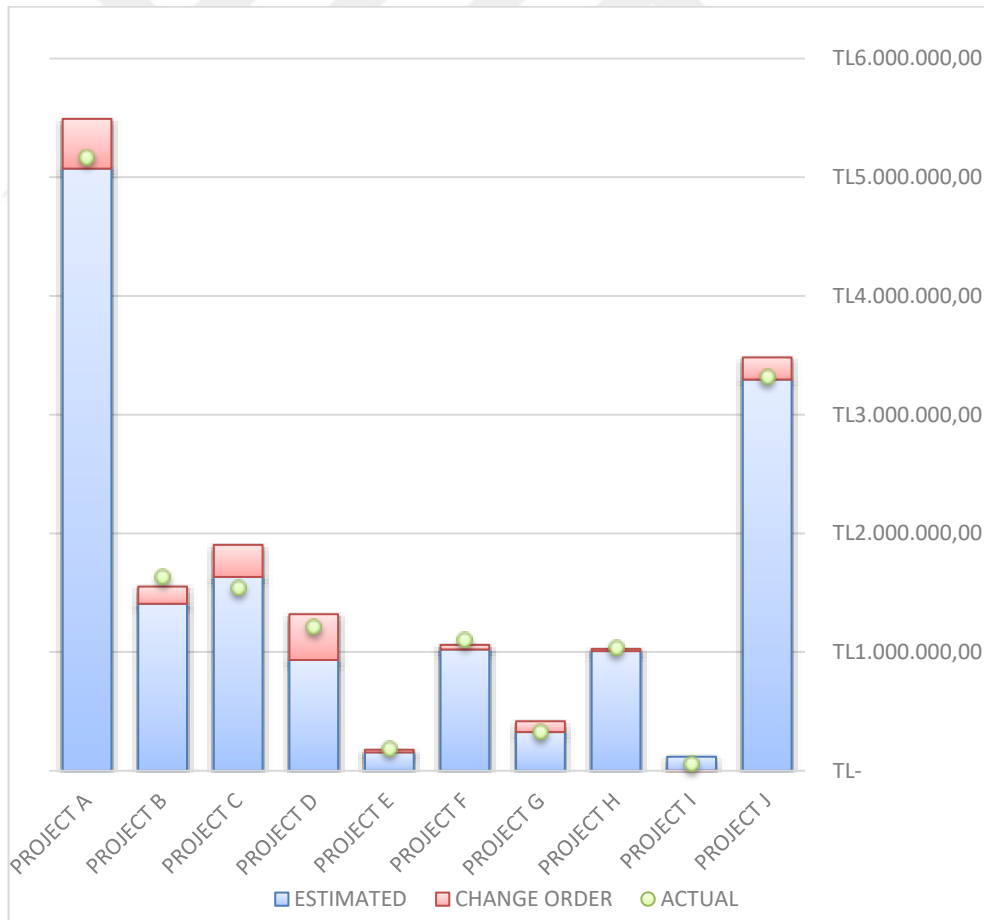


Figure 4.12 : Demonstration of unexpected changes.

Cost variation causes were investigated by the frequency of the variations or change orders in terms of different project parameters. It was mentioned that project type and tendering conditions are effective on variation and change orders. It is summarized the percentages of change orders and variations on Figure 4.13a. Change order frequency was higher when the percentage was higher. 4 of the 10 projects had more than 10% change orders. The frequency was decreased to 3 if the change orders were between 10% and 5% of actual cost. Further 2 of the 10 projects were under 5% and only 1 of them was under 0%. On the other hand, the frequency of the variations was not aligned with the change order frequency. The highest number of variations were seen under 5% and the following frequency of the variations was 3 of the 10 projects that had more than 10% of the estimated cost.

In the further analyses, the impact of the project type, delivery method and payment type on variation and change orders had been investigated. The results were sorted by variations in office projects and other projects besides change orders in office projects and other projects. Contractual results were sorted by project delivery methods and payment type. Design-build and bid-build projects were examined to detect the impact of project delivery methods. Lump sum and cost plus fixed fee payments were two payment types in 10 projects.

Office projects were 7 of 10 projects and 57% of office projects resulted in less than 5% variations. All of the other projects had more than 10% variations of the estimated cost. Change order frequency of office projects was correlated based on the percentage of the actual cost. Other projects had more than 10% in 2 projects and between 5% and 10 in 1 projects. Bid-build projects were 7 of the 10 projects and variations of the bid-build projects were under 5% in 4 projects. Design-build projects had both cost overruns and cost underruns however 2 of the 3 design-build projects resulted in cost overruns. 5 of the 10 projects completed more than 5% of its actual cost and 2 of them were more than 10%. Design-build projects had change orders more than 10% in 2 of 3 projects. Percentage of variations on cost-plus-fixed-fee payment type of projects prorated the frequency. Change orders in cost plus fixed fee projects, however, resulted in more than 10% in 3 of 5 projects. Lump sum projects had variations in 2 of 6 projects with more than 10% of estimated cost and more than 10% change orders in 3 of 4 projects.

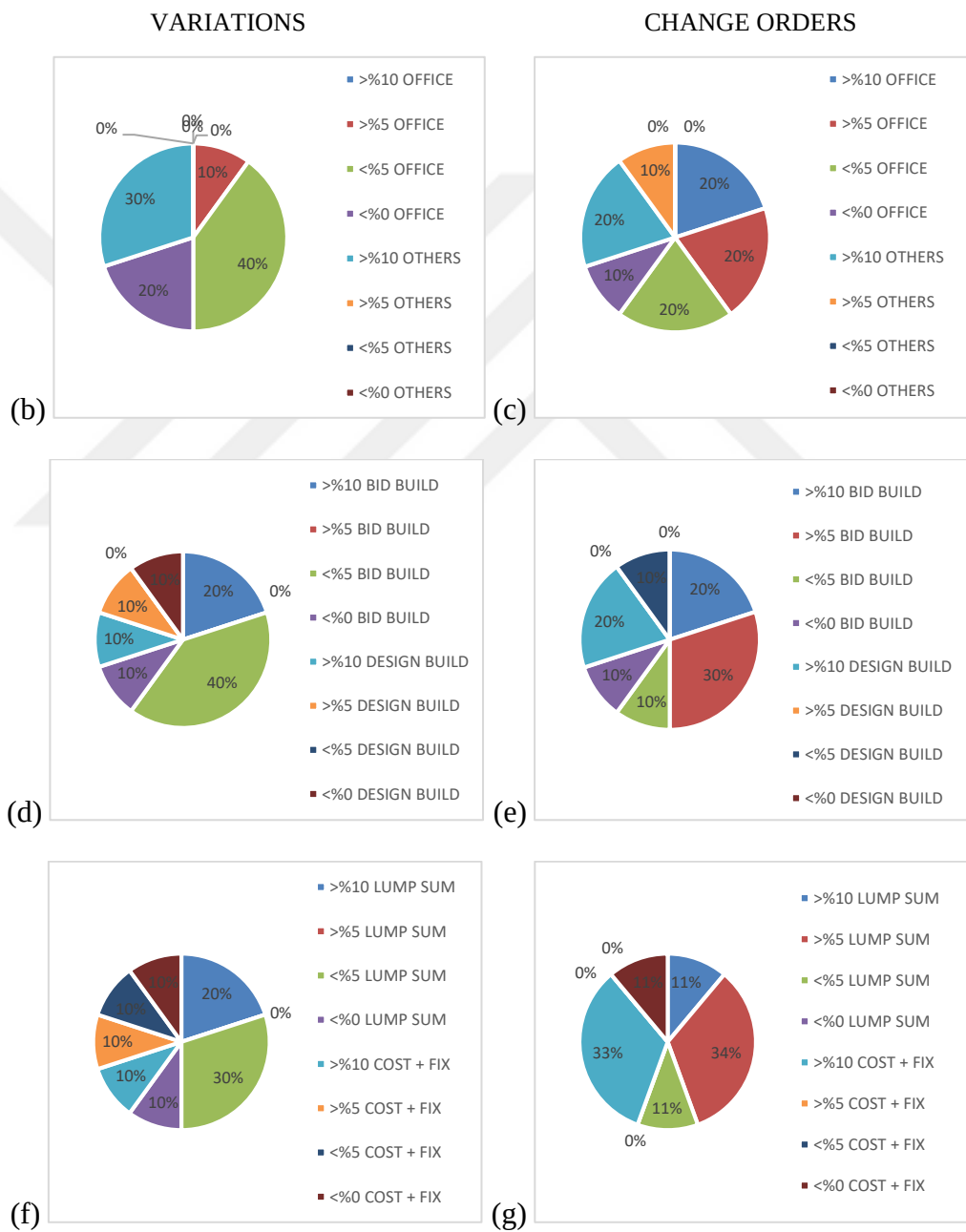


Figure 4.13 : The frequency of percentages variations and change orders for 10 projects.

Table 4.12 summarizes the data presented and points out that the percentages of the total change orders and total variations for 10 projects. Both cost overruns and cost underruns were seen on the table. Furthermore, the range of the variation and change orders were unstable. There were projects that change orders increased the actual cost, however, the variation still negatively such as Project C. Another significant example is Project G had 27,9% change orders of its actual cost however the actual cost is increased only 0,2%. Project D is an example of highly divergence project because of 29,7% of the variation and 31,9% of the change order.

It was also seen that the impact of the mentioned percentages may be different depending on the total cost of the construction. In the column of variation cost, amount of the project variations of Project D (277.192,60 TL) and Project B (229.109,63 TL) were approximately same value, however, two variation cost of projects was 29,7% for Project D and 16,3% for Project B. As the direct opposite, 8,1% cost variation of Project A and 8,9% cost variation of Project B and the cost differ 273.919,99 TL from each other.

Table 4.13 was created by omitting work items, which were out of the scope in all projects. Following divisions were removed from the further analysis: Special Construction, Fire Suspension, HVAC Systems, Integrated Automation, Communication, Electronic Safety and Security, Earthwork. All percentages of each work item were presented based on actual cost. The aim of Table 4.13 was to detect the impact of each work item on the project's actual cost. The work items were sorted out and significant work items were detected for each project. It is intended to find the repetitive work items which had a high impact on cost.

The work items, which covered 80% of the actual cost of each project, had been highlighted in Table 4.13. Detection of significant work items was applied throughout the Pareto principle. The principle of Pareto, the Italian economist, claims that approximately 80% of the consequences result from 20% of the causes and the principle is applied to quality management by Juran (Bunkley, 2008). Except for 2 projects (Project E, Project H), it was seen that the highest percentage work item was “Finishes (Division 09)” in all of the projects.

The following work items were the list of 80% of the actual cost in all projects analysed in case studies. (Table 4.15);

- Existing Conditions
- Concrete
- Metals
- Openings
- Finishes
- Equipment
- Furnishings
- Electrical

After omitting the work items that are out of scope, Figure 4.14 shows the distribution of work items according to the frequency of each work item in 80% of actual cost. In other words, the frequency in 80% of the total actual cost consists of shown work items in Table 4.13. Finishes included in 80% of work items of all ten project. Openings and Furnishings were the second frequent work items in the distribution. Existing Conditions, Concrete, Metals, Equipments, and Electrical works were in the highest work items however the number of frequency were 3 or less (Figure 4.14).

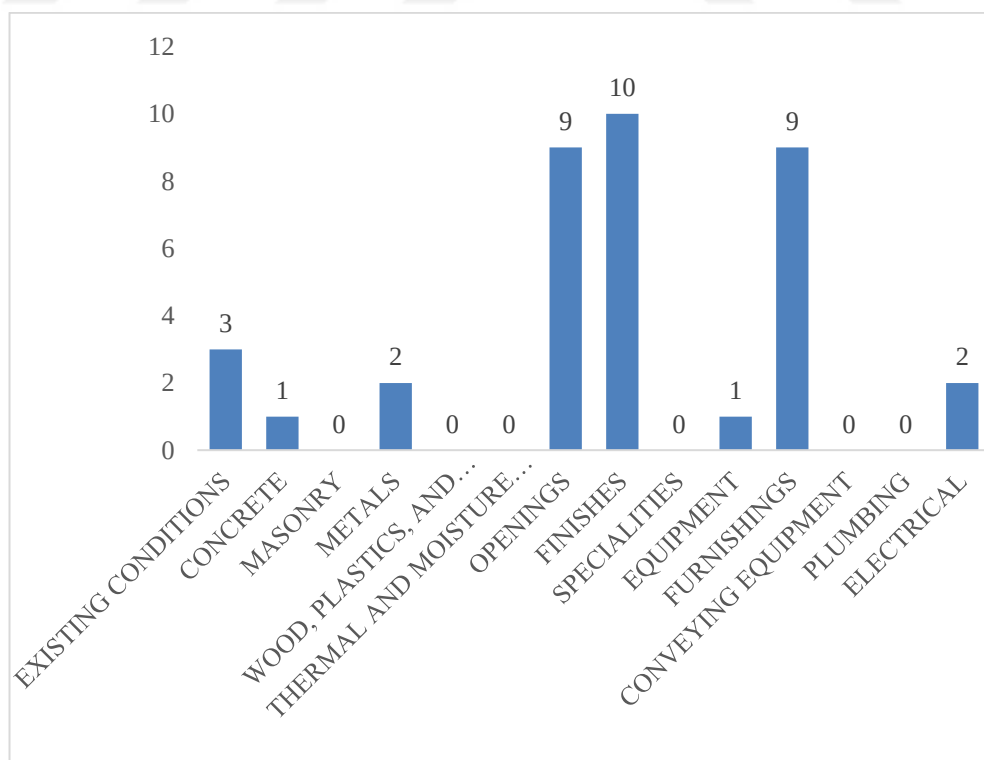


Figure 4.14 : Sorted work items according to the Pareto Principle.

Table 4.11 : Sum of information of each project.

Project Code	Estimated Cost (EC)	Actual Cost (AC)	Variation Cost (VC)= (AC-EC)	Change Order Cost (CoC)	Percentage of Variation (VP)= (VC/EC)	Percentage of Change Order (CoP)= (CoC/AC)
Project A	5.072.563,25 TL	5.169.653,49 TL	97.090,24 TL	418.878,40 TL	1,9%	8,1%
Project B	1.406.743,70 TL	1.635.853,33 TL	229.109,63 TL	144.958,42 TL	16,3%	8,9%
Project C	1.632.780,18 TL	1.539.471,07 TL	-93.309,11 TL	270.427,86 TL	-5,7%	17,6%
Project D	933.187,68 TL	1.210.380,28 TL	277.192,60 TL	385.635,38 TL	29,7%	31,9%
Project E	154.993,01 TL	188.615,19 TL	33.622,17 TL	21.820,93 TL	21,7%	11,6%
Project F	1.021.691,91 TL	1.104.807,45 TL	83.115,54 TL	38.628,31 TL	8,1%	3,5%
Project G	325.915,25 TL	326.618,95 TL	703,70 TL	91.138,46 TL	0,2%	27,9%
Project H	1.008.125,10 TL	1.035.053,14 TL	26.928,04 TL	18.531,58 TL	2,7%	1,8%
Project I	118.106,90 TL	58.464,00 TL	-59.642,89 TL	- 1.598,69 TL	-50,5%	-2,7%
Project J	3.295.671,94 TL	3.319.637,39 TL	23.965,45 TL	186.441,23 TL	0,7%	5,6%

Table 4.12 : Cost percentages of each work items.

		PROJECT A	PROJECT B	PROJECT C	PROJECT D	PROJECT E	PROJECT F	PROJECT G	PROJECT H	PROJECT I	PROJECT J
Work Item Division Code	Work Item Division Name	% of Total Budget	% of Total Budget	% of Total Budget	% of Total Budget	% of Total Budget	% of Total Budget	% of Total Budget	% of Total Budget	% of Total Budget	% of Total Budget
Division 02	EXISTING CONDITIONS	1,57%	5,12%	2,22%	7,30%	7,73%	3,59%	10,22%	1,41%	14,11%	3,48%
Division 03	CONCRETE	1,34%	1,45%	0,05%	21,33%	3,54%	0,69%	0,15%	0,09%	0,28%	1,88%
Division 04	MASONRY			0,01%	0,71%	0,21%	0,27%	0,28%		0,86%	0,03%
Division 05	METALS	8,32%	20,88%	25,07%	4,49%	1,77%	1,44%	5,05%	0,56%	3,25%	2,93%
Division 06	WOOD, PLASTICS, AND COMPOSITES	0,74%	0,04%			0,61%		0,53%			0,00%
Division 07	THERMAL AND MOISTURE PROTECTION	0,04%	1,80%	0,63%	3,02%		0,30%		0,28%		3,11%
Division 08	OPENINGS	8,53%	23,41%	15,07%	9,93%	5,06%	14,06%	22,08%	12,18%	32,24%	10,69%
Division 09	FINISHES	41,48%	31,52%	32,91%	30,08%	27,44%	38,76%	37,94%	34,94%	37,92%	39,00%
Division 10	SPECIALITIES	0,51%	1,67%	0,15%	1,64%		0,95%	0,00%	1,07%	0,66%	1,49%
Division 11	EQUIPMENT					13,68%					4,59%
Division 12	FURNISHINGS	21,74%	9,90%	8,72%	16,76%	26,99%	31,53%	20,58%	47,62%	10,69%	31,81%
Division 14	CONVEYING EQUIPMENT			6,85%							0,00%
Division 22	PLUMBING	2,40%		2,27%	4,73%	0,14%	2,13%	3,17%	1,85%		0,84%
Division 26	ELECTRICAL	13,33%	4,22%	6,05%		12,85%	6,27%				0,13%

Figure 4.15 demonstrates the percentages of most significant work items. All Finishes cost between 25% and 45% of actual costs. Relatedly, Furnishings was also another highest cost percentage in 9 projects. The range of percentage in Furnishings was wider. The highest percentage was 47,62% and the lowest percentage was 8,72%. The average of Finishes was 35,20% in 10 projects and the average of Furnishings was %22,63 of total actual cost in 9 projects. On the other hand, the percentage of three work items that took apart in all projects were not higher than 5% of the actual cost (Table 4.15). The mean percentage of Equipment (1,83) was listed due to the high cost of Equipment in Project E.

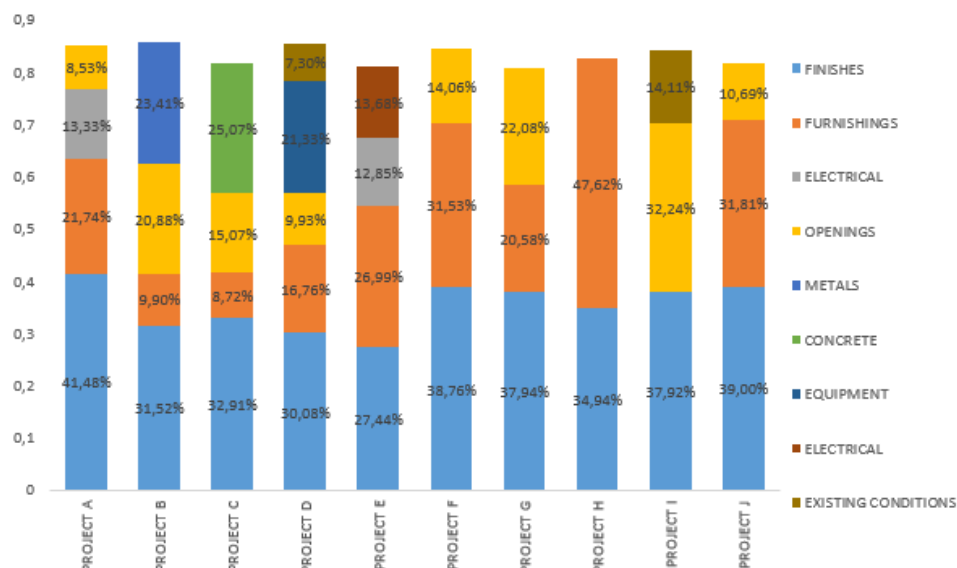


Figure 4.15 : Highest ranked work items according to the Pareto Principle

It is shown that in the mean percentage of cost variations and change orders on each division and reflection on total cost in Figure 4.16. mean of variations on each divisions and mean of change orders on each divisions are independent from total project cost. On the other hand, mean of variations on total cost and mean of change orders on total cost are correlated with total actual cost of the project.

Table 4.13 : Sorted list of highest cost percentage of work items.

	PROJECT A		PROJECT B		PROJECT C		PROJECT D		PROJECT E	
Sort Order	Work Item Division Code	% of Total Budget	Work Item Division Code	% of Total Budget	Work Item Division Code	% of Total Budget	Work Item Division Code	% of Total Budget	Work Item Division Code	% of Total Budget
1	FINISHES	41,48%	FINISHES	31,52%	FINISHES	32,91%	FINISHES	30,08%	FINISHES	27,44%
2	FURNISHINGS	21,74%	OPENINGS	23,41%	METALS	25,07%	CONCRETE	21,33%	FURNISHINGS	26,99%
3	ELECTRICAL	13,33%	METALS	20,88%	OPENINGS	15,07%	FURNISHINGS	16,76%	EQUIPMENT	13,68%
4	OPENINGS	8,53%	FURNISHINGS	9,90%	FURNISHINGS	8,72%	OPENINGS	9,93%	ELECTRICAL	12,85%
5	METALS	8,32%	EXISTING CONDITIONS	5,12%	CONVEYING EQUIPMENT	6,85%	EXISTING CONDITIONS	7,30%	EXISTING CONDITIONS	7,73%
6	PLUMBING	2,40%	ELECTRICAL	4,22%	ELECTRICAL	6,05%	PLUMBING	4,73%	OPENINGS	5,06%
7	EXISTING CONDITIONS	1,57%	THERMAL AND MOISTURE PROTECTION	1,80%	PLUMBING	2,27%	METALS	4,49%	CONCRETE	3,54%
8	CONCRETE	1,34%	SPECIALITIES	1,67%	EXISTING CONDITIONS	2,22%	THERMAL AND MOISTURE PROTECTION	3,02%	METALS	1,77%
9	WOOD, PLASTICS, AND COMPOSITES	0,74%	CONCRETE	1,45%	THERMAL AND MOISTURE PROTECTION	0,63%	SPECIALITIES	1,64%	WOOD, PLASTICS, AND COMPOSITES	0,61%
10	SPECIALITIES	0,51%	WOOD, PLASTICS, AND COMPOSITES	0,04%	SPECIALITIES	0,15%	MASONRY	0,71%	MASONRY	0,21%

Table 4.13 : Sorted list of highest cost percentage of work items.

	PROJECT F		PROJECT G		PROJECT H		PROJECT I		PROJECT J	
Sort Order	Work Item Division Code	% of Total Budget	Work Item Division Code	% of Total Budget	Work Item Division Code	% of Total Budget	Work Item Division Code	% of Total Budget	Work Item Division Code	% of Total Budget
1	FINISHES	38,76%	FINISHES	37,94%	FURNISHINGS	47,62%	FINISHES	37,92%	FINISHES	39,00%
2	FURNISHINGS	31,53%	OPENINGS	22,08%	FINISHES	34,94%	OPENINGS	32,24%	FURNISHINGS	31,81%
3	OPENINGS	14,06%	FURNISHINGS	20,58%	OPENINGS	12,18%	EXISTING CONDITIONS	14,11%	OPENINGS	10,69%
4	ELECTRICAL	6,27%	EXISTING CONDITIONS	10,22%	PLUMBING	1,85%	FURNISHINGS	10,69%	EQUIPMENT	4,59%
5	EXISTING CONDITIONS	3,59%	METALS	5,05%	EXISTING CONDITIONS	1,41%	METALS	3,25%	EXISTING CONDITIONS	3,48%
6	PLUMBING	2,13%	PLUMBING	3,17%	SPECIALITIES	1,07%	MASONRY	0,86%	THERMAL AND MOISTURE PROTECTION	3,11%
7	METALS	1,44%	WOOD, PLASTICS, AND COMPOSITES	0,53%	METALS	0,56%	SPECIALITIES	0,66%	METALS	2,93%
8	SPECIALITIES	0,95%	MASONRY	0,28%	THERMAL AND MOISTURE PROTECTION	0,28%	CONCRETE	0,28%	CONCRETE	1,88%
9	CONCRETE	0,69%	CONCRETE	0,15%	CONCRETE	0,09%			SPECIALITIES	1,49%
10	THERMAL AND MOISTURE PROTECTION	0,30%							PLUMBING	0,84%

Figure 4.16 : Mean percentages of each work items based on actual cost, variations and change orders.

	Mean of Actual Cost of Division/ Total Actual Cost	Mean of Variations on Each Divisions	Mean of Change Orders on Each Divisions	Mean of Variations on Total Cost	Mean of Change Orders on Total Cost
FINISHES	35,20%	3,85%	11,73%	-1,72%	4,05%
FURNISHINGS	22,63%	15,75%	12,67%	0,75%	2,03%
OPENINGS	15,32%	-6,42%	6,03%	-3,97%	0,51%
METALS	7,38%	23,68%	-10,28%	-0,62%	0,42%
EXISTING CONDITIONS	5,67%	51,52%	23,36%	-0,34%	1,42%
ELECTRICAL	4,28%	2,28%	10,70%	0,02%	0,10%
CONCRETE	3,08%	43,03%	2,59%	1,67%	1,82%
EQUIPMENT	1,83%	0,07%	10,13%	0,47%	0,48%

4.12 Interview Analysis of the Case Studies

The interviews were conducted with the team members which were mentioned in section 2. Open-ended questions were followed during the interviews.

Primarily, the reasons for the variations and the change orders were questioned and the responses were listed as below:

Project A:

- Material changes were decided during the project process (interviewees A, B and C),
- Change of usage for a specified area and indecisiveness of the new usage of the area (interviewees A, B, and C),
- Lack of knowledge for materials and selection of materials which did not exist in the market in the design phase (interviewee C).

Project B:

- Incompatibility of design and existent site conditions (interviewee B and C),
- Bad communication and relations with the building management (interviewees A and C).

Project C:

- The appointed cost target of the owner (interviewees C),
- Material changes in order to decrease the project cost (interviewees A and C),
- Cancellation of works or delay of the works for the future budget possibilities (interviewee C).

Project D:

- The increase of concrete works unexpectedly due to the reinforcement of the structure (interviewees A, B, and C),
- Owner requests for custom-made furniture although it was considered as loose furniture in the estimated cost (interviewees A, B, and C),
- The selections of high-quality finishing materials by the owner (interviewee A),
- The long duration of the works and reworks in thermal and insulation works due to unqualified workers (interviewees A, B, and C).

Project E:

- Additional works due to scope change during the construction (interviewees A and C),
- Rejection of claims for overhead expenses (interviewees A and C).

Project F:

- Owner requests for quality change in materials (interviewees A, B, and C),
- Additional works for signage (interviewees A and B),
- Approval of alternative materials (interviewee A).
-

Project G:

- Additional furnishing works (interviewees A, B and C),
- Incorrect pricing due to lack of design documents (interviewee A).

Project H:

- The increase of quantities during the construction by owner (interviewees A and C),
- Errors in estimation during the tender stage(interviewees A and C).

Project I:

- Change of scope (interviewees A, B and C),
- Exploring alternative subcontractors (interviewees A).

Project J:

- Unexpected site conditions and additional works for the changes (interviewees B and C),
- Additional works to the scope (interviewees A, B, and C).

After the detection of the reasons, precautions and actions to avoid these changes are discussed with every interviewee for their specified work area and the statements are summarized below:

The aspect of Interviewee A:

"Cost estimation and cost control is a continuous process. As a part of my role research for the new subcontractors is important to reduce the costs. It is also obliged to find new firms and suppliers due to contract conditions. We try to reflect the risks to subcontractors due to the contract between the owner and our company. These obligations may be the duration of the project, health and safety clauses or assurance type and duration. Therefore it is not easy to negotiate with every subcontractor.

Another role of our department is relations with the client and project management consultants because during the construction both of the sides are trying to keep their budget and contract rights. Changes mean negotiations with the owner every time. If we do not explain the reasons for the claim with right documentation it may be rejected or cause discussions.

Cost mistakes result from short tender conditions or unexpected conditions during the construction. Tender duration and documentation are important for the accurate estimate. Besides changes in conditions are more important for the stability of the estimated cost because the additional costs to resist the risks may result in loose of the project.”

The aspect of Interviewee B:

"Planning is the most important part of a project completion date is appointed. The completion date of the project affects the completion of all works. All works need to be designated due to this date. Therefore changes force the site team mostly because some of the changes require technical difficulties. They also cause rework and problems with subcontractors at the site.

We are trying to foresee the technical problems about the design and their practicability. Owners and designers may be obstinate in design thus to find an applicable new technics is our concern and it is added into the schedule as a margin in case of changes."

The aspect of Interviewee C:

“Management of all process, departments inside the company or conditions with the other stakeholders is my responsibility. The challenging part is the relations and agreements on conditions with the owners. Our company involves both the design stage and construction stage of the projects, therefore, we are qualified to comment on the documentation of tender or technical ability of the design during the tender process. The project of a convinced owner by these comments is more successful than other owners'. The changes before the sign of the contract add value to the project. It is also a matter of reliance on the contractor and to create this trust we explain all the reasons and deficiencies with technical and quantitative facts. These changes may be on the design and materials or conditions of the contract. Regulations and conditions in contract affect our costs and we reflect it to the owner with the proposal. Hence, mitigation of the contract conditions also reduces the owner's cost. While commenting on a design we try to convince that we manage value engineering in the projects.”

Table 4.14 : Causes of the cost variations in the case study projects based on the interview data

Project A:	Material changes
	Change of scope
	Deficiencies in technical knowledge
Project B:	Deficiencies in technical knowledge
	Lack of communication
Project C:	Coordination with the owner
	Material changes
	Change of scope
Project D:	Unexpected works at site
	Material changes
	Material changes
Project E:	Change of scope
	Lack of communication
Project F:	Material changes
	Change of scope
Project G:	Change of scope
	Omissions on the estimated cost
Project H:	Change of quantities
	Errors in the estimation phase
Project I:	Change of scope
	Communication with Subcontractors
Project J:	Unexpected works at site
	Change of scope

4.13 Discussions of the Results

The results of the case studies and interviews were discussed through the literature researches in this section. Suggested factors affecting the cost variations in previous studies were listed in Chapter 2 furthermore the case studies were analysed to detect the impact of the variations and finally, interviews were focused on specific factors for the case studies.

The impact of the cost variations may be various although it is specified with a similar type of constructions. It was established in the case studies that cost variations were differed by both the quantity of the cost and the percentage of the estimated cost. Every construction project is unique by the reason that construction is a combination of science and humanities. Despite the similar characteristics of the fit-out projects, conditions during the constructions were different from each other in terms of decision mechanism, management of the project or environmental conditions. For instance, if it would be possible to experiment by keeping all conditions same, the experience or motivation of the workers would be different for each project.

Cost variations and change orders are caused by the same factors, however, there are more factors affecting the cost variations. It was illustrated that the frequency of the cost variations and change orders were not resulted correspondingly (Figure 4.13a). The reason behind this result can be caused by unexpected events during the construction. Another reason is the desire to decrease the actual cost. Even though the change orders of Project C increased the actual cost 17,6%, the actual cost was lower than the estimated cost. It was explained in the interviews due to the change of the scope by the cancellation of some works. This decision can be explained with the coordination of project participants and cost control management during the construction process in literature researches.

Project specifications are significant parameters to examine the results. Project type, project delivery method, and payment methods were questioned to analyse the results. It was seen that cost variation frequency in office projects was distributed under 10% of estimated cost. By the reason that office projects are usually lead by a team of the client company, they were called "the owner" in previous chapters. This team consists of people who were aimed with a determined budget by top management authorities of the company. It is seen in the Table 4.13 that 60% of the cost variations occurred in

bid-build procurement method and 50% of the cost variations occurred in lump sum projects. In addition the highest percentage of cost variations are established between 0% and 5 % of actual cost. This results shows that cost variations are common in bid-build and lump sum price constructions. The reason behind the result can come forward through the deficiencies in tender process by the reason of uncompleted design, lack of time during the construction or unforeseen conditions on site. Change orders are occurred more than 5% of the actual costs in the half of the bid-build case studies hence it is highlighted that change orders are common in bid-build constructions. The reasons of the change orders can be explained by the similar reasons behind the cost variations for this results. Both lump sum payment and cost plus fixed fee are affected by change orders. Consequently the existing budget and the struggle of the ensure the estimated cost is affected by project delivery methods and payment types.

Table 4.14 summarize the mean of the cost variations and change orders of 10 case studies. Although most of the mean values are cost overruns in work items, there are also cost underruns. The deviant changes for one of the projects may affect the consequences however their impact on the actual cost are remarkeable. Selection of the controllable work items and their impact on cost variation can be a strategy to lead the design during the construction. Deficiencies or unclear subjects can be highlighted during the meeting and the decisio mechanism can be stimulated ahead of time.



5. CONCLUSIONS AND RECOMMENDATIONS

This research aimed, with regard to data collected from ten fit-out construction projects, to explore the significant work items on cost variations between estimated cost and the actual cost. The standard work item based method is a common method in order to control the budget for fit-out construction projects. It, however, needs to be considered and supported with possible causes, which is indicated to have a significant impact on the amount of variations and change orders.

Awareness of the cost variations is crucial for the mitigation of the consequences.

For instance, clauses in the contract may be revised with more appropriate ones to the project before it is signed thus, the consequences may be reduced during the construction. The major problem with identifying the effects of cost variations is that the discussed factors embrace all kind of project types, contract types, and organizations. Identification of specified project characteristics helps to distinguish the causes and the effects of cost variations.

Cost is accepted as the most significant success criteria of a project. The success of the projects is generally built on the achievement of the goals determined for the cost. Therefore consequences of variations which occurred between actual cost and the estimated cost should be controlled and the actions should be decided to decrease the impact.

5.1 Conclusions

Case studies were analysed to detect the work items due to their impact on actual cost in order to achieve the main aim of this research. As a result of the analyses and comparison of each project's findings the following nine work item were established and the reasons behind are explained:

- Finishes were the most significant work item on fit out projects. All of the projects had Finishes in their 80% of the budget. The mean percentage for Finishes was 35,20% of actual cost. It was excepted that there are several kinds of finish works

and materials due to the nature of fit-out projects. Although mean of the variations was under %5 (3,85%), it is certain that the impact of the cost variations is serious. The average of the change orders was found 11,85% of the actual cost for Finishes.

- Furnishings were the second significant work items with 22,63% of actual cost. The mean of the cost variations and change orders were in balance (15,75% and 12,67% in order). The reason for these balance can be considered as that Furnishings are the last works on schedule and they are replaceable easily and usually added in the scope in case of budget availability.
- Openings were the third work items that took place in the actual cost (15,32%). By the reason that there are glass partitions and doors in every project either it only has shell or not. The number of office projects affects the impact of the percentage of the Openings, as well. Openings were also correlated by the mean of cost variations (6,42%) and change orders (6,03%). This consequence may be commented because the changes are the significant reasons for the variations.
- Metals were identified to be the fourth significant item on the actual cost. Metals are usually used as decoration objects in fit out projects however in some of these projects had stairs and additional structures which affect the rate of the cost. The mean cost variations were detected 23,68% more than the estimated cost besides the change orders are 10,28% of the actual cost.
- Existing Conditions(5,67%), Electrical works (4,28%), Concrete works (3,08%) and Equipments (1,83%) were the rest of the significant items on actual cost.

Interviews were conducted to establish the reasons for the findings in case studies. Open-ended questions were asked to the team members of projects. The responses of the team members are categorized by the factors found in previous researches. The common causes of the occurred variations are listed below:

- Change of quantities
- Change of scope
- Communication with Subcontractors
- Coordination with the owner
- Deficiencies in technical knowledge

- Errors in the estimation phase
- Lack of communication
- Material changes
- Omissions on the estimated cost
- Unexpected works at site

The data, achieved by this research, have results for both contractors and owners in order to decrease the impact of the cost variations. Contractors require to analyse all specifications taken from design and tender documentation as a variable to their estimation. Cost variation and change order percentages presented for each significant work item can be used to detect contingencies in their estimated cost as a preliminary start. The cost variation factors mentioned in results are considerable variables in order to highlight the precautions and decisions to mitigate the cost variations in the execution phase. This research gives awareness to the owners about the possibility and the frequency of the cost variations. These results may be used to negotiate the contract conditions between contractors and owners. In addition, owners can predict the variations in the cost and finalize their budget for the selection of possible contractors. Another way to get benefit from these results is to guide to the decision of the project delivery system and the payment methods.

This study had been conducted on 10 case studies due to the difficulties of getting permission from the companies. It is certain that more case studies result in more accurate findings. The obtained data had been organized through logical acceptances during the analyses by the reason of unclarity of the data in the documented files.

Consequently, finishes, furnishings, openings, metals, existing conditions, electrical works, concrete works, equipment are the most significant work items on actual cost based on the case studies performed, change orders that caused by deficiencies in the design and construction and communication problems are the frequently encountered factors for cost variations. Findings of this research are significantly important for the change of the consequences of cost variations. These changes certainly will affect the success of the projects in terms of the cost.

5.2 Recommendations

Each project should be examined by its own specialties, however, the reasons of the cost variations are highly connected to each other. Changes in scope and documentation are connected with the cost variations directly. In addition to changes communication between project team and all stakeholders has significant role on cost variations. Changes and communication effects should be considered during the project lifecycle.

Work items in fit-out projects are similar and the cost variations which occur in high cost items in total cost lead project to cost overrun or cost underrun. Finishings and Furnishings should be planned in terms of specifications and possible changes during the constructions. Opening, Metals and Existing Conditions are detected as important as the highest cost items for the fit out projects.

The results can be evaluated to guide both researches and professional practices and the significant work items on cost variations were found out in fit-out project. As a result of the analysis, it was decided to use various approaches and technics to achieve a significant result. It was seen that these results cannot be generalized or directly used in applications due to the wide scale of variables.

This research may be accepted as a narrow scale of research for fit-out projects as this study searched on ten projects by a single organization. Future researches may be conducted with more projects based on used methodology in this research. Furthermore different function and size of projects by different organizations should be added to enhance the credibility of the findings.

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APPENDICES

APPENDIX A: Master Format titles and divisions breakdown list.

APPENDIX B: Utilization permit of case study information.



APPENDIX A

Master Format titles and divisions breakdown list.

Categories of the Work Items

02 00	EXISTING CONDITIONS
02 20	Assessment
02 30	Subsurface Investigation
02 40	Demolition and Structure Moving
02 50	Site Remediation
02 60	Contaminated Site Material Removal
02 70	Water Remediation
02 80	Facility Remediation
03 00	CONCRETE
03 10	Concrete Forming and Accessories
03 20	Concrete Reinforcing
03 30	Cast-in-Place Concrete
03 40	Precast Concrete
03 50	Cast Decks and Underlayment
03 60	Grouting
03 70	Mass Concrete
03 80	Concrete Cutting and Boring
04 00	MASONRY
04 20	Unit Masonry
04 40	Stone Assemblies
04 50	Refractory Masonry
04 60	Corrosion-Resistant Masonry
04 70	Manufactured Masonry
05 00	METALS
05 10	Structural Metal Framing
05 20	Metal Joists
05 30	Metal Decking
05 40	Cold-Formed Metal Framing
05 50	Metal Fabrications
05 70	Decorative Metal
06 00	WOOD, PLASTICS, AND COMPOSITES
06 10	Rough Carpentry
06 20	Finish Carpentry
06 40	Architectural Woodwork
06 50	Structural Plastics
06 60	Plastic Fabrications
06 70	Structural Composites
06 80	Composite Fabrications

Master Format titles and divisions breakdown list.

Categories of the Work Items

07 00	THERMAL AND MOISTURE PROTECTION
07 10	Dampproofing and Waterproofing
07 20	Thermal Protection
07 30	Steep Slope Roofing
07 40	Roofing and Siding Panels
07 50	Membrane Roofing
07 60	Flashing and Sheet Metal
07 70	Roof and Wall Specialties and Accessories
07 80	Fire and Smoke Protection
07 90	Joint Protection
08 00	OPENINGS
08 10	Doors and Frames
08 30	Specialty Doors and Frames
08 40	Entrances, Storefronts, and Curtain Walls
08 50	Windows
08 60	Roof Windows and Skylights
08 70	Hardware
08 80	Glazing
08 90	Louvers and Vents
09 00	FINISHES
09 20	Plaster and Gypsum Board
09 30	Tiling
09 50	Ceiling
09 60	Flooring
09 70	Wall Finishes
09 80	Acoustic Treatments
09 90	Painting and Coating
10 00	SPECIALITIES
10 10	Information Specialties
10 20	Interior Specialties
10 30	Fireplaces and Stoves
10 40	Safety Specialties
10 50	Storage Specialties
10 70	Exterior Specialties
10 80	Other Specialties
11 00	EQUIPMENT
11 10	Vehicle and Pedestrian Equipment
11 20	Commercial Equipment
11 30	Residential Equipment
11 40	Foodservice Equipment

Master Format titles and divisions breakdown list.

Categories of the Work Items

11 50	Educational and Scientific Equipment
11 60	Entertainment and Recreation Equipment
11 70	Healthcare Equipment
11 80	Facility Maintenance and Operation Equipment
11 90	Other Equipment
12 00	FURNISHINGS
12 10	Art
12 20	Window Treatments
12 30	Casework
12 40	Furnishings and Accessories
12 50	Furniture
12 60	Multiple Seating
12 90	Other Furnishings
13 00	SPECIAL CONSTRUCTION
14 00	CONVEYING EQUIPMENT
14 10	Dumbwaiters
14 20	Elevators
14 30	Escalators and Moving Walks
14 40	Lifts
14 70	Turntables
14 80	Scaffolding
21 00	FIRE SUSPENSION
22 00	PLUMBING
22 10	Plumbing Piping
22 30	Plumbing Equipment
22 40	Plumbing Fixtures
22 50	Pool and Fountain Plumbing Systems
22 60	Gas and Vacuum Systems for Laboratory and Healthcare Facilities
23 00	HVAC SYSTEMS
25 00	INTEGRATED AUTOMATION
26 00	ELECTRICAL
26 10	Medium-Voltage Electrical Distribution
26 20	Low-Voltage Electrical Distribution
26 30	Facility Electrical Power Generating and Storing Equipment
26 40	Electrical Protection
26 50	Lighting
27 00	COMMUNICATION
28 00	ELECTRONIC SAFETY AND SECURITY

Master Format titles and divisions breakdown list.

Categories of the Work Items

31 00	EARTHWORK
32 00	EXTERIOR IMPROVEMENTS
33 00	UTILITIES
34 00	TRANSPORTATION
35 00	WATERWAY AND MARINE CONSTRUCTION
40 00	PROCESS INTERCONNECTIONS
41 00	MATERIAL PROCESSING AND HANDLING EQUIPMENT
42 00	PROCESS HEATING, COOLING, AND DRYING EQUIPMENT
43 00	PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT
44 00	POLLUTION AND WASTE CONTROL EQUIPMENT
45 00	INDUSTRY-SPECIFIC MANUFACTURING EQUIPMENT
46 00	WATER AND WASTEWATER EQUIPMENT
48 00	ELECTRICAL POWER GENERATION



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