Driving Force of Cost Escalation and its Impact Level on Commercial Building Projects in Adama Town of Ethiopia.

Yobsen Bekele Zewudie

A Thesis Submitted to

Departement of Civil Engineering (Construction Engineering and Management)

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Civil Engineering specialization in Construction Engineering and Management

Office of Graduate Studies
Adama Science and Technology University

July, 2023
Adama, Ethiopia

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Advisor: Lemma Beressa, PhD

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APPROVAL PAGE FOR THESIS

I hereby certify that the recommendation and suggestion given by the thesis review by the committees are appropriately incorporated into the final thesis entitled "Driving Force of cost escalation and its impact level on commercial building projects in Adama Town of Ethiopia" by Yobsen Bekele.

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Major Advisor/Supervisor Signature Date

We, the undersigned, members of the Board of Examiners of the thesis Yobsen Bekele have read and evaluated the thesis entitled "Driving Force of cost escalation and its impact level on commercial building projects in Adama Town of Ethiopia" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Civil Engineering(Specialization in Construction Engineering and Management).

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DECLARATION

I declare that this thesis entitled "Driving Force of cost escalation and its impact level on commercial building projects in Adama Town of Ethiopia "is my work and has not been submitted to Adama Science and Technology University for a similar purpose. The references used in this thesis are duly recognized by proper citations.

Yobsen Bekele Zewudie	____________________________	____________
Name of student	Signature	Date

RECOMMENDATION OF ADVISOR

I, the major advisor of this research, hereby certify that I have closely advised the student while developing this thesis and read the draft thesis entitled “Driving Force of cost escalation and its impact level on commercial building projects in Adama Town of Ethiopia” prepared under my guidance by Yobsen Bekele. Therefore, I recommend the submission of the thesis to the department for further review and evaluation.

Lemma Beressa, Ph.D.	________________________	________________
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LIST OF ABBREVIATIONS AND ACRONYMS

AHP	Analytic Hierarchy Process
ANCOVA	Analysis of covariance
BIM	Building Information Modeling
C.E.P	Cost escalation percentage
Cce	Cause of Cost Escalation
CCI	Construction Cost Index
D.U	Discrete universe
ELRVSM	Enter linear regression variable selection method
FDM	Fuzzy Delphi Method
IMF	International Monetary Fund
MV	Membership value
NGCF	National Gross Capital Formation
OECD	Organization for Economic Co-operation and Development
PACs	price adjustment clause
ROi	Regression Output
SEi	Severity Effect
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
WDS	Weighted Degree of Severity
WPI	Wholesale Price Index

ABSTRACT

The driving forces behind cost escalation in Adama Town's commercial building projects need to be investigated comprehensively to devise effective strategies that adequately address the issue. Understanding the impact level of each driving force on cost escalation is crucial to promoting a sustainable construction industry in Adama town. The objectives of this study involve investigating the underlying reasons for cost escalation in commercial building projects in Adama town, assessing the extent of their impact on the buildings, and creating a model to predict and manage such escalations. Through a detailed literature review, 29 causes of cost escalation were identified. The current study adopted a fuzzy triangular function to identify the impact level of the identified causes influencing cost escalation from the contractors', consultants', and owners' views by using questionnaires. This study utilized descriptive and inferential research methods for data analysis. The results are in line with many previous studies in that the problem of cost escalation is a phenomenon in the construction of commercial building projects. The top ten serious reasons for cost escalation in Adama town commercial building projects are National political instability, resource supply shortage, Inaccurate estimating, Inflation, market trend, length of time to complete the project, suspension, and strike of work, improper planning, transportation cost, and exchange rate fluctuation. Furthermore, the study presents models for predicting the percentages of cost escalation for commercial building projects in the Adama Town. The developed models are based on the linear regression analysis method and a statistical fuzzy approach. The top 10 causes of cost escalation have been incorporated into the models as independent variables. The validity of the developed models has been checked to show the prediction accuracy of the developed models, and it has been noted that the linear regression-based models can accurately assess the expected cost escalation of any future commercial building projects in Adama town at a level of confidence of 56.37 percent, while statistical fuzzy-based models can predict the cost escalation of commercial building projects in Adama town at a level of confidence of 53.67 percent. Therefore, the study suggested using linear regression-based models rather than statistical fuzzy-based models in predicting the cost escalation of commercial building projects in the Adama town. However the study may have limitations due to respondents' lack of knowledge, but future research can address this by using larger samples and better training. The developed models offer a promising starting point for better cost management in the construction industry in Adama townand beyond.

Keywords:*Cost escalation, commercial building, models, validity, contractor, client, consultantant.*

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

The construction industry is a significant contributor to the economic growth and development of a country. In Adama town, this sector is experiencing a substantial increase in the number of commercial building projects, reflecting a growing demand for infrastructure development and economic activities in the area (Tekalign, T, 2016). However, recent studies have highlighted the growing challenge of cost escalation in the construction industry, which has adverse consequences for project completion rates, budget overruns, and overall project success (Zewdu, M. F, 2019). The driving forces behind cost escalation in Adama Town's commercial building projects need to be investigated comprehensively to devise effective strategies that adequately address the issue. Understanding the impact level of each driving force on cost escalation is crucial to promoting a sustainable construction industry in Adama town. Assessing the impact of these forces will help stakeholders such as contractors, project managers, and policymakers identify which factors are most critical, allocate resources more effectively, and implement measures to control and mitigate the negative consequences of escalating costs (Mbachu, J., & Nkado, R., 2004).

Given the various factors involved, accurately modeling the percentage of causes of cost escalation in projects has proven to be challenging. One method for modeling cost escalation is the use of statistical or econometric models. (Elhag. T. & Boussabaine. H. et. al, 2005) developed a multivariate regression model to predict the cost and time overruns in the UK construction industry. The model had an adjusted R-squared value of 0.61, indicating that these predictors explained 61% of the variation in cost overruns; while (Choi H.H. & Kim, H.J. et. al, 2004) used probabilistic and fuzzy models for analyzing the construction delay and cost escalation. Another approach to modeling cost escalation is employing artificial intelligence techniques, such as machine learning algorithms (Kimar. A. & Arditi. D. , 2012) and artificial neural networks (Zhang. G., & Li. H. , 2013). Kimar and Arditi found that a support vector machine-based model outperformed multiple regression and decision tree models in predicting construction cost overruns, with an average accuracy of 93%. Similarly, Zhang and Li (2013) reported that a hybrid artificial neural network and genetic algorithm model achieved a 92% success rate in identifying cost overrun factors in Chinese construction projects.

This paper aims to provide an overview of the causes of cost escalation in building construction projects and examine its impact level for research, focusing on the importance of understanding these causes to minimize their occurrence. Understanding the causes of cost escalation in construction projects and their impacts is crucial for developing model by using linear regeression and statistical fuzzy based for effective strategies and policies to manage and minimize cost escalation.

1.2. Statement of the Problem

The construction industry plays a significant role in the economic growth and development of a region. Commercial building projects contribute to this growth by providing numerous opportunities for businesses, employment, and infrastructure development. Adama town, in Ethiopia, has experienced a boom in construction projects in recent years, owing to its strategic location and growing population. In turn, this has led to a surge in the demand for commercial buildings to cater to the expanding needs of the community. However, one of the major challenges faced by stakeholders involved in these projects is the escalation of costs (Ahady, 2017).

Cost escalation in commercial building projects can negatively impact the overall success of the projects, leading to delays; budget overruns, financial losses, and compromised quality of the construction (Belay, & Jain, et. al, 2023). This problem is often exacerbated by a lack of understanding of the driving factors behind cost escalation and their impact level on the project's cost performance. Consequently, the identification of these factors and their management is crucial to ensure the timely delivery of commercial building projects within stipulated budgetary constraints, contributing to the economic growth of Adama town.

This study seeks to address the problem of cost escalation in commercial building projects in Adama Town, Ethiopia. It intends to identify the causes of cost escalation, determine the impact level of the identified causes on the overall cost, and develop a cost escalation model that would aid project stakeholders in mitigating these challenges in future endeavors.

Understanding the drivers of cost escalation and their respective impact levels will provide valuable insight into devising effective strategies and recommendations for controlling cost overruns, ultimately contributing to the successful delivery of commercial building projects in Adama town, Ethiopia (Belay, & Jain, et. al, 2023).

1.3. Objective

1.3.1. General objective.

To investigate the causes of cost escalation and analyze their impact level on the cost escalation of commercial building projects' in Adama town and develop model.

1.3.2. Specific objectives.

- ✓ To identify the cause of cost escalation for commercial building projects in Adama.
- ✓ To determine the impact level of the identified cause of cost escalation on commercial buildings.
- ✓ To develop a cost escalation model for commercial building projects.

1.4. Research Question

- ✓ What are the causes of the commercial building project's cost escalation?
- ✓ What are the critical causes of commercial building projects' cost escalation on the contract breach?
- ✓ How do commercial building projects' cost escalation models develop?

1.5. Significance of the Research

The significance of this research lies in the ability to identify and quantify the major causes that contribute to cost escalation in commercial building projects within the Adama Town. By understanding of the factors identified by study in the construction projects, stakeholders can better anticipate challenges, address potential risks, and make informed decisions in managing project costs effectively. The development and validation of two models for predicting the percentages of cost escalation further enhance the practical applications of the study, as they allow stakeholders to estimate cost escalations more accurately.

Moreover, this study offers valuable insights for policymakers and regulatory bodies in identifying areas where improvements can be made to prevent cost overruns in ongoing and future commercial building projects in the region. The findings contribute to the wider literature on cost escalation, promoting more effective and efficient management of building projects, and supporting sustainable economic growth in Adama town and similar regions.

1.6. Scope of the Study

Only one country, Ethiopia, specific area of Adama town is studied geographically in this study. The survey is only open to, contractors, and consultants that are registered in this country and clients based on the length of experience, educational background, position, and stake in the projects. None of the questions were administered elsewhere. This research does not include all of the many construction-related projects; it focuses on building construction projects, specifically commercial building projects in Adama town. The driving factor of cost escalation for commercial building projects and its impact level has been chosen as the study's primary emphasis among other project management facets. The research in this area was limited to identifying the reason for significant cost escalation and its consequences, as well as improving cost escalation impacts.

Due to time constraints and financial constraints, the research was only able to examine active commercial building projects in Adama town.

1.7. Limitations of the Study

The unavailability of up-to-date and comprehensive data on the construction sector in Adama town posed challenges in data collection, leading to incomplete or insufficient data in some aspects of the research. There could be potential biases in the data collected from government sources, private companies, and other stakeholders in the construction industry, affecting the objectivity of the study. The research was conducted within a limited time frame, which may have restricted a more in-depth analysis, including extensive primary data collection, such as surveys to substantiate the findings or address identified gaps in the literature.

The lack of a standardized model or framework for examining cost escalation and its impact level in the Ethiopian context may have restricted the comparability or generalizability of the findings. The identification and analysis of the driving forces of cost escalation and their impact levels were based primarily on the researcher's interpretations and understanding of the literature, which could introduce potential subjectivity or bias in the finding.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

Introduction Cost escalation is a major challenge faced in construction projects, particularly in commercial building projects. The construction industry is characterized by high levels of complexity, risk, uncertainty, and competitive pressures, which contribute to cost overruns, schedule delays, and low levels of productivity performance. The increasing demand for commercial buildings necessitates the need to understand the factors leading to cost escalation, their impacts, and possible mitigation strategies. The purpose of this literature review is to investigate, analyze, and model the factors leading to cost escalation in commercial building projects. By examining various sources, this review aims to provide an understanding of the causes, impacts, and potential mitigation strategies for managing cost escalation in future commercial building projects. Cost Escalation: Definition and Factors According to (Moselhi, & Ahmad, K. et. al, 2013), cost escalation refers to the increase in the estimated or actual costs of a project beyond the original budget. This typically occurs due to various factors such as changes in material prices, inflation, economic conditions, inaccurate cost estimates, technological advancements, and changes in labor costs (Odeh, A. M., & Battaineh, H. T., 2002).

(Hwang, B. G., & Leong et. al, 2013) argue that factors contributing to cost escalation can be categorized into three main categories: macro-economic, micro-economic, and project-related factors. Macroeconomic factors include changes in international oil prices, foreign exchange rates, interest rates, financial policies, and inflation (Ahiaga-Dagbui, D. D., Love, P. E. D. et. al, 2018). Micro-economic factors include poor management practices, inadequate planning, low labor productivity, and inadequate cost estimation (Odeh, A. M., & Battaineh, H. T., 2002). Project-related factors include design changes, scope changes, material price fluctuations, project complexity and size, environmental factors, and project duration (Ahiaga-Dagbui, D. D., Love, P. E. D. et. al, 2018). Impacts of Cost Escalation in Commercial Building Projects Cost escalation in commercial building projects have several implications for the project stakeholders. First, it leads to significant financial losses for the project owner as well as contractors and subcontractors (Fayek, A. R., & Elazouni, A. M. et. al, 2012). This financial risk associated with cost escalation can negatively impact the profitability of companies involved in the project (Hwang & Leong, 2013). Second, cost escalation may lead to disputes and conflicts among project stakeholders, particularly when it comes to allocating responsibility for the additional costs (Ahiaga-Dagbui, D. D., Love, P. E. D. et. al, 2018). Such disputes can lead to delays in project completion, further increasing the overall project cost (Olawale, Y. A., & Sun, M. , 2015).

Finally, cost escalation may impact the quality of the completed project (Love, P. E. & Ahiaga-Dagbui, D. D. et. al, 2013). In an attempt to reduce costs or compensate for cost overruns, contractors may cut corners on material quality or workmanship, leading to a lower-quality final product (Odeh, A. M., & Battaineh, H. T., 2002). Mitigation Strategies for Managing Cost Escalation Effective cost management is key to minimizing the impact of cost escalation in commercial building projects. Several mitigation strategies have been proposed in the literature, which can be grouped into three categories: organizational, technical, and contractual strategies (Fayek, A. R., & Elazouni, A. M. et. al, 2012). Organizational strategies involve improving overall project management practices, communication among project stakeholders, and risk management processes (Love, P. E. & Ahiaga-Dagbui, D. D. et. al, 2013). This may include using project management tools and software, fostering a culture of collaboration, and employing experienced project managers with relevant skills and expertise (Olawale, Y. A., & Sun, M. , 2015).

2.2. Cost Escalation

Cost escalation is an increase in the contract price during Contract implementation based on the existence of an event or occurrence. These increases will be a contract provision to cater to the cost of material, labor, and machinery due to continuing price changes over time. Cost escalation is also defined as the difference between the unexpected final actual cost of a construction project at completion and the contract amount, agreed by and between the client and the contractor during the signing of the contract. Cost escalation is explained in different ways such as a decrease in the purchasing power of money with time; Used to estimate the future cost of a project; that is, to escalate current costs into the future or to move the cost to the future by using predictive escalation index for planning and budgeting; Used to bring historical costs to the present; that is to compare the present cost based on the past by using historical escalation index, it will also be associated with escalation concepts of present and future worth (Ababa, 2015)

It is inevitable to determine the essential factors that affect the construction price index to boost the precise cost and overall investment calculation for buildings. The study's findings show that eleven indicators impact the construction cost indices; however, the most significant one is the consumer price index (NGUYEN, P. T., et. al, 2021). Broadly speaking, the purpose of building an industry-level forecasting model is to treat its predictions as targets for the industry to plan its future workload and use of limited resources, such as land, financial capital, and manpower. In essence, the tender price index forecasting model allows the industry to assess current against future prevailing price levels to achieve higher price competitiveness by either lowering costs or increasing productivity (Hua, 2000).

2.3. Causes of Cost Escalation

Material price changes in the construction sector have lately occurred for a variety of reasons, including those that make it particularly sensitive to average cost hikes in the local and worldwide markets. The causes of project cost escalation may originate from either external or internal pressures that are being applied to the construction building project at a more detailed level, the causes of construction project cost escalation are usually generated from either design or construction activities; the design-generated causes include design changes, design errors, omissions and operational improvements (Ababa, 2015).

Internal and external cost escalation can be distinguished. External cost escalation factors include technical changes, changes in owner expectations, changes in competitor activities, changes in governmental regulation, changes in the economy, and lastly demographic changes in society, i.e. economic difficulties such as inflation and deflation. The inflation rate is one of the main factors of cost overrun, which deviates the building materials prices cost over time it makes Building materials prices nonlinear behavior in the construction rates as it shows an increase and decrease in the prices over time; mainly affected by the inflation rate, which is one of the most critical factors of cost overrun in construction projects (Musarat, 2020).

To reduce the cost overrun effect on construction projects having a long duration the most suitable way is to deal with the inflation rate during the project duration, observe the prices behavior over time, and building materials prices should be forecasted incorporated by the inflation rate and amended in the initial Bill of Quantities to avoid the cost overrun (Musarat, 2020). So needs developing a budget estimation model which integrates the past prices of the materials with the inflation rate and foresees the risk of deviating the prices over time at the initial stage while setting up the project budget rather than making an adjustment through the contingency cost (Musarat, 2020).

2.4. Global and Regional Trends of Cost Escalation

The IMF cited various factors, including trade tensions, geopolitical issues, and weakening manufacturing output driving these trends (IMF , 2019). The ongoing trade disputes, particularly between the United States and China, have resulted in tariffs being imposed on various goods, leading to increased costs for producers and consumers. The tariffs have significant knock-on effects on supply chains and global trade, ultimately raising production costs and consumer prices (UNCTAD. , 2018). The increasing frequency and severity of natural disasters, such as storms, droughts, and floods, have had significant impacts on agriculture, infrastructure, and housing, leading to increased costs for governments and businesses. The United Nations (UN) has estimated that the damages caused by climate-related disasters cost the global economy more than $300 billion annually (UN, 2018). Rising labor costs are another factor contributing to global cost escalation. The cost of labor has been increasing in major economies such as the United States and China. This is due to factors such as rising minimum wages, a tightening labor market, and a shift towards higher-skilled, higher-paid jobs (Bureau of Labor Statistics, 2021). The cost of raw materials has been on an upward trend globally due to various factors such as supply constraints, geopolitical tensions, and increased demand. For instance, prices of commodities like steel, aluminum, and copper saw significant spikes in recent years (World Bank, 2021). Rapid urbanization, particularly in emerging markets, has led to increased demand for housing, infrastructure, and public services. This has put pressure on governments to invest in infrastructure development, driving up construction costs (UNCTAD. , 2018).

The global population continues to grow, increasing the demand for food, housing, education, healthcare, and other essential services. This growing demand has resulted in increased costs for governments, businesses, and consumers. While technological innovations can lead to cost savings and productivity gains, the rapid pace of advancement also means increased costs for companies to keep pace with the latest technologies. Investing in research, development, and adoption of new technologies is often expensive and can contribute to cost escalation (World Economic Forum, 2018). Political uncertainty and tensions between countries can contribute to cost escalation through various channels, such as increased defense spending, the imposition of trade barriers, and the disruption of supply chains due to geopolitical risks (European Central Bank, 2019). Governments worldwide are implementing new regulations, particularly in areas such as environmental protection, labor rights, and data privacy. Compliance with these regulations often implies increased costs for businesses, which can ultimately result in higher prices for consumers (OECD, 2019).

2.5. Regional Trends of Cost Escalation in the Horn of Africa

According to the (World Bank, 2021), Ethiopia's annual inflation rate rose to 19.2% in 2020 from 15.8% in 2019, driven by food prices. This rate is higher compared to the rates of neighboring countries (World Bank, 2021). The increase in inflation has led to escalating costs in various sectors, including agriculture, construction, and consumer goods (World Bank. , 2021). Ethiopia is the second-most populous country in Africa, with a population growth rate of 2.5% per year (World Bank, 2021). The rapid increase in population has exerted pressure on limited resources, contributing to the rise in the cost of living, especially in urban areas (Yazid, M. W., & Zewdu, W. J. , 2019). The Horn of Africa is particularly vulnerable to climate change, with frequent droughts and floods leading to reduced agricultural productivity, increased food insecurity, and displacement of populations (United Nations Environment Programme (UNEP), 2021). These climate-induced challenges have significantly contributed to cost escalation in Ethiopia, such as increasing food prices and the cost of rebuilding after natural disasters (Tesfaye.Y. & Haregeweyn N. et. al, 2019).

Ethiopia has experienced internal conflicts, especially in the Tigray region, leading to insecurity, human rights abuses, and economic challenges. This instability has also contributed to rising costs, particularly concerning humanitarian assistance and rebuilding infrastructure

(Human Rights Watch, 2021). Ethiopia has embarked on ambitious development plans, including infrastructure projects aimed at increasing economic growth and reducing poverty. However, these projects have also led to rising public debt, causing the government to implement austerity measures and devalue the local currency, further contributing to cost escalation (International Monetary Fund (IMF), 2020).

2.6. Causes of Cost Escalation in Commercial Building Projects

Cost escalation in commercial building projects refers to the increase in the cost of construction over time. This can be due to various factors such as material and Labor Costs Construction materials and labor costs are two significant factors that contribute to cost escalation in commercial building projects (Oyer, S. A., 2021). According to a report by (CCI , 2020), the cost of construction materials such as steel, concrete, and lumber can vary significantly due to changes in global markets, tariffs, and trade policies. In addition, the demand for skilled labor can also impact costs, as shortages can lead to increased wages and delays in project completion (Rider Levett Bucknall , 2021). General inflation can also contribute to cost escalation in construction projects. Construction costs, including material and labor, are impacted by inflation (Yong, Y. C., & Mustaffa, N. E. , 2012). Therefore, it is crucial to consider inflation factors when estimating project costs and creating budgets, as failing to account for inflation can lead to financial risks and losses (Gajendran, T.& Brewer, G. et. al , 2019). Design Changes and Project Modifications Changes in design and project specifications can also lead to cost escalation (Singh, A., & Nakra, P. , 2019). These changes may be required due to updated regulations, owner preferences, or unforeseen conditions at the construction site. Such modifications can impact material and labor requirements, potentially leading to higher costs and delays in project completion (Koushki, P. A. & Al-Rashid, K. et. al, 2005). Procurement Methods: The method of procurement chosen for a commercial building project can influence cost escalation. Several studies have found that certain procurement methods, such as traditional lump-sum contracts, may lead to higher cost escalation compared to alternative contractual arrangements (Chan, D. W. & Kumaraswamy, M. M. et. al , 2009).

By selecting the appropriate procurement method, cost escalation and its impact on project delivery can be minimized. Construction-Related Challenges Construction-related challenges are another factor that can contribute to cost escalation. On-site issues, such as poor weather conditions, accidents, or lack of access to materials and equipment, can lead to delays and increased costs (Owolabi, J. D. & Ojelabi, R. A. et. al, 2014). Sustainability requirements, such as incorporating green building features and meeting environmental regulations, can also raise the overall cost of a commercial building project (Kwak, Y. H. & Sadatsafavi, H.et. al, 2013).

2.7. Project-Related Factors that Leading to Cost Escalation

Poor project planning and estimation: Inadequate planning and unrealistic cost estimation can lead to cost escalation during the project execution. It is essential to have a well-defined project scope, budget, and timeline to avoid unexpected expenses (Flyvbjerg, B., & Rothengatter, W. et. al , 2003). Changes to the project design, either due to client requirements or technical reasons, can cause additional costs and also extend project timelines (Odeck, J., 2004). The uncertainty of currency exchange rates and inflation rates can lead to considerable cost escalation, especially for projects with a long duration or projects in countries with unstable economies (Creedy, G. D. & Wong, J. K. et. al , 2008). The cost of construction materials and equipment can increase with time due to various factors such as market demand, transportation costs, and inflation. This can lead to cost escalation in projects with a long duration (Aibinu, 2002). Labor costs represent a significant portion of the total project cost, and any increase in these costs can have a significant impact on the overall project budget (Lahdenpera P. , 2012). Labor costs could increase due to inflation, labor shortages, or changes in labor laws and regulations. Projects may require permits and approvals from various governmental and environmental agencies, and any changes in regulations during the project lifecycle can lead to increased costs. Additionally, failure to comply with environmental standards can result in fines and penalties, further escalating project costs. Failing to adequately identify, quantify, and manage risks during project planning can lead to cost escalations during project execution. Risks related to labor, materials, equipment, regulations, and market conditions should be thoroughly assessed and managed (Schieg. M , 2006).

2.8. Market-Related Factors that Cause Construction Cost Escalation

The cost of construction materials like steel, cement, and wood can fluctuate due to market demand and supply, global economic factors, or trade policies. These fluctuations can impact the overall cost of construction projects (Cho. J. & Kang. C. et. al, 2016). The cost and availability of skilled labor can escalate construction costs. Factors influencing labor costs include labor productivity, unionization, wage rates, and regional labor market conditions (Touran. A. & McKelvey. D., 2011). Economic factors, such as inflation, interest rates, and exchange rates, can impact construction costs by affecting material, labor, and equipment costs (Rwelamila. P. D. & Meyer. C. , 2006). The level of competition in the construction market can impact construction costs. Higher competition can drive prices down, while lower competition can lead to increased costs (Cho. J. & Kang. C. et. al, 2016).

The construction industry is cyclical, and costs tend to increase during periods of high demand and decrease during periods of low demand. The business cycle plays a significant role in construction cost escalation (Hwang, B. G., & Le, V. D., 2018). Changes in regulations and policies, such as building codes, permitting processes, and zoning restrictions, can have a significant impact on construction costs (Touran. A. & McKelvey. D., 2011). Changes in fuel and energy prices can impact construction costs by affecting transportation, material production, and equipment operation costs (Rwelamila. P. D. & Meyer. C. , 2006). Disruptions in the supply chain, such as natural disasters, geopolitical tensions, or other unexpected events, can cause an increase in the cost of construction materials and lead to construction cost escalation (Hwang, B. G., & Le, V. D., 2018). The adoption and implementation of new technologies can lead to increased construction costs, especially in the short term (Touran. A. & McKelvey. D., 2011). The demands and expectations of clients can impact construction costs, especially if they require high-quality materials, specialized labor, or unique design features (Rwelamila. P. D. & Meyer. C. , 2006).

2.9. Institutional and Regulatory Factors that Cause Cost Escalation of Construction Building

The introduction of new or changing existing regulations and building codes can lead to higher construction costs (Flyvbjerg, B., & Rothengatter, W. et. al , 2003). Regulations may require the use of specific materials, construction methods, or design standards that can be more expensive to implement. Furthermore, compliance with regulations and codes adds administrative tasks and processes, resulting in increased time and cost. Zoning laws and land use restrictions, aimed at controlling urban growth and ensuring the appropriate use of land, can increase the cost of construction. The restriction on the availability of land or specific land uses can lead to higher land prices, increasing overall construction costs (Tu. Huy Q. & Kent Hatcher et. al, 2015)projects on the environment and society, can add significant costs to construction projects. The permitting process often takes considerable time to complete, which can delay project timelines and increase costs. Additionally, mitigation measures or adjustments to project plans may be required to meet environmental regulations, further escalating costs. Labor regulations, including labor wage rates, working hours, and employment conditions, can directly impact the cost of construction projects. For instance, policies that increase wages or require additional benefits for employees can result in higher labor costs for construction projects. Moreover, regulations may also limit the overall availability of skilled or low-cost labor in certain locations; further increasing labor costs (Hillebrandt & Joseph Cannon, 2013).

The requirement to adhere to safety and quality standards can increase the cost of construction projects. Ensuring a safe working environment and compliance with quality requirements often necessitates additional personnel, training, and procedures, which can escalate overall project costs (Love, P. E. & Ahiaga-Dagbui, D. D. et. al, 2013). Various taxes and duties imposed by governments can significantly impact construction costs. These may include taxes on construction materials, equipment, or imported construction components, as well as duties on the import of construction materials and machinery (Eichholtz, and John M. Quigley. et. al , 2010).

2.10. Managing and Measuring Cost Escalation

To measure and manage cost escalation in a construction project first, it is important to understand its driving force of it (Morris, 2006). This is especially critical in the existing situations, where price fluctuations have been so unpredictable that it has been difficult to foresee or estimate what bid prices might be (Wondimu, 2019). The poor cost predictability and the right skew of the distribution of final costs should be a cause for concern for project managers and project owners, and may ultimately lead to project cost overruns unless the project cost contingency is large enough to account for these uncertainties (Welde, 2021). Even if some changes to the scope of work may be necessary to accommodate changing needs and to deliver higher benefits, the volume of escalations may indicate a risk of poor efficiency because of delays, opportunistic behavior, and conflicts. Large and complex contracts have a higher probability of escalation even if their average escalations are lower than for small contracts (Welde, 2021).

Managing and measuring cost escalation is crucial for organizations to plan, execute, and close projects successfully. Cost escalation refers to the increase in the costs of goods, materials, labor, or services over time, impacting project budgets, timelines, and resources (Flyvbjerg, 2002). Accurate measurement and effective management of cost escalation can help organizations mitigate financial risks and meet project goals. Here are some strategies to manage and measure cost escalation, with each supported by relevant citations:

Planning for contingencies: Businesses might set aside money for unanticipated price increases. This strategy entails building a financial safety net that can pay for unforeseen expenses and control risks brought on by variables like inflation, scope changes, or supplier problems. Cost estimation techniques: Accurate cost estimation and forecasting models can help organizations monitor and control project costs better. Various techniques can be employed, including historical cost data, expert judgment, and parametric cost models (Creedy, 2010). Indexation: By using established cost indices, organizations can account for potential future cost increases in their project budgets. The construction cost index, labor cost index, and consumer price index are some examples of the cost escalation factors that may be considered. Risk management: A comprehensive risk management strategy ensures that potential cost escalations are identified, analyzed, and mitigated. Risk management approaches may involve techniques like sensitivity analysis, scenario analysis, and Monte Carlo simulation to measure the potential impacts of cost escalations on project success (Baccarini, 2015). Contract management: Organizations can work with vendors, suppliers, and contractors to manage cost escalation risks through proper contract management. Strategies include selecting appropriate pricing models, incorporating escalation clauses, and regular monitoring of contract performance (Chong, 2012). Benchmarking: Benchmarking against similar projects in the industry facilitates early identification of cost escalation trends and provides opportunities for improvement. Benchmarking helps organizations effectively manage and measure cost escalations using best practices comparisons (Lim, 2020)

2.11. Internal and External Causes of Cost Escalation

Construction projects around the world have a very poor performance record concerning being completed within cost, time, and quality objectives (Aljohani, 2017). It has many factors to change from time to time as the condition of the construction market is affected by other external and internal pressure. The total number of factors are 175 factors some of which are repeated in almost every study such as the contractor's poor site management and supervision skills, and other which occur in specific contexts such as high transportation cost due to fuel shortages (Aljohani, 2017) The studies show that the main causes of cost overrun differ from country to country. Data analysis revealed that cash flow and financial difficulties, slow payments, inflation, fluctuation in material prices, and the number of change/extra work orders were reported as the most commonly occurring cost escalation factors in a construction project (Ahmed, 2018). This work is an overview of the causes of the cost overrun in many developing countries as it has been found that all the factors are not similar to every project in developing countries though some of them are common such as poor management, fluctuation of material prices inaccurate material estimates and financial status of the contractor (Ahady, 2017). The five most significant factors these causing price escalation on building projects were fluctuation in foreign currency exchange rates, an increase in material cost and unstable market conditions, unbalanced demand and supply of construction materials, limitation of construction material producer's capacity, and project schedule changes (Belay, & Jain, et. al, 2023).

2.11.1. Internal causes of cost escalation.

Poor project management, design changes, inadequate cost estimation, labor productivity issues, and inefficient resource allocation are internal causes that can lead to cost escalation in construction projects (Kerzner, 2017; Sweis, 2013; Memon, 2014; Heywood, 2017; Yang, 2016).

2.11.2. External causes of cost escalation.

External factors contributing to cost escalation include economic fluctuations, changes in government regulations, fluctuating market conditions, force majeure events, and rapid technological changes (Ibironke, 2013; Aibinu, 2002; Elhag, 2005; Zuo, 2014; Gugel, 2003).

These internal and external factors can impact the overall project budget by causing delays, material shortages, or increased labor costs, which make it crucial to effectively manage resources and adapt to unforeseen changes in project planning and execution.

Table 2. 1 Internal Causes of Cost Escalation and External Causes of Cost Escalation from a literature review.

Reference	Cause of cost escalation
	Internal Causes of Cost Escalation
(Kerzner, 2017).	Poor project management: Inefficient planning, scheduling, and management of resources can lead to increased project costs.
(SIis, et al.2013).	Design changes: Frequent changes in the project design or scope can lead to cost overruns and delays.
(Memon, et al., 2014).	Inadequate cost estimation: Inaccurate or incomplete cost estimation at the project planning stage can lead to cost escalations during implementation.
(Heywood, 2017).	Labor productivity: Low productivity of the workforce can result in an increased need for labor hours, impacting overall project costs.
(Yang, 2016).	Inefficient resource allocation: Improper allocation of resources, both human and material, could lead to delays and inefficiencies, causing an increase in project costs.
	External Causes of Cost Escalation:
(Ibironke, et al., 2013)	Economic factors: Fluctuations in the economy, such as changes in interest rates, inflation, and exchange rates, can inflate project costs.
(Aibinu & Jagboro, 2003)	Government regulations: Changes in government policies and regulations can impact project costs by affecting factors such as taxation, permitting, and environmental regulations.
(Elhag, et al., 2005)	Market conditions: Fluctuations in the market, including changes in the demand for construction materials and labor, can lead to cost escalations.
(Zuo & Rosen, 2014).	Force majeure events: Unforeseen events such as natural disasters, political unrest, or labor strikes can negatively impact project costs by causing delays, material shortages, or increased labor costs.

(Gugel & Russell, 2003).	Technological changes: Rapid changes in technology can result in outdated designs and construction methods, leading to increased costs for necessary revisions or upgrades.

Source: from different literature review 2023

2.12. Impacts of Cost Escalation on Contracting Parties

The major impact of cost escalation during construction can result in loss of profit to the contractor, project delay, shortage of finance to contractors and additional cost, delay of a project to end user, and damage to the relationship between parties. If the worst cases happen the contractor and in the rear case the client may lead to Bankruptcy (Ababa, 2015).

Many studies had conducted to investigate the effects of cost overrun in construction projects. Thus all studies across many developed and developing countries indicated that cost overrun represents a global phenomenon in construction projects. Consequently, the prevention or minimizing of cost overrun is an important priority in the construction industry and it's difficult to prevent cost overrun fully. Key construction parties, including government policymakers, owners, contractors, consultants, subcontractors, suppliers, laborers, managers, engineers, and researchers, could benefit from the findings and recommendations of factors contributing to cost overrun in construction projects (Mahamid, 2014). This knowledge can support the government in improving the regulations to meet the construction market needs, owners in planning, designing, and evaluating policy, contractors and managers in planning and taking external and internal risks when costing and scheduling contracts, consultants in applying comprehensive contract information, and workers in conducting their day-to-day activities (Mahamid, 2014). The literature review can help with in-depth research and give practitioners a thorough understanding of the knowledge topic. This will close a significant research and practice gap.

When costs increase unexpectedly or without contractual provisions, the profitability of the project may be reduced for both the contractor and the client (Chan, 2002). Contractors might have to absorb the increased costs, leading to reduced margins, while clients may be forced to pay more than expected for the project or experience diminished returns on their investment.

Delays in project completion: When costs escalate, contractors may slow down the work, delay the project, or even halt it temporarily to renegotiate the contract terms or secure additional funding (Aibinu, 2002). Such delays can negatively impact project schedules, reduce efficiency, and increase the overall project cost for both parties.

Adverse effects on relationships: Cost escalation can strain the relationships between contracting parties, leading to disputes, legal conflicts, and potential project failures (Hatush, (2012). In some cases, cost escalation can also damage the reputation of the parties involved, affecting their ability to secure future contracts or collaborations.

Poor-quality outcomes: To cope with escalating costs, contractors might resort to cost-cutting measures such as using cheaper materials, reduced labor input, or illegal practices like bribery (Ahmed, 2018). Such actions may lead to poor-quality deliverables, which can harm the project's successful completion and the buyer's satisfaction. Claims and disputes: Cost escalation can lead to contractual claims and disputes between the contracting parties, which can result in costly litigation and arbitration proceedings. These legal battles can negatively impact both parties financially and may cause deteriorating relationships, increased risks, and project delays (Akinsola 2012). Cost escalation can have severe impacts on both contracting parties in terms of financial losses, project delays, relationship strains, and legal disputes. Parties need to address the possibility of cost escalation in their contracts through provisions such as price adjustment clauses, escalation indices, and risk-sharing mechanisms. This ensures a fair distribution of risks and minimizes unforeseen effects on the parties involved.

Table 2. 2 Effects of cost escalation on contracting parties.

Effect author	Less profit to the client	Less profit to the contractor	Cash-flow problems	Disputation	End-user satisfaction	Company failure
Mbahu and Nkado (2004)	✓	✓	✓	✓	✓	✓
Zainudeen, Kumari, &Seneviratne 2008		✓	✓			
Ahmed et al. (2003)			✓	✓		

Charoenngam and Sriprasert (2001)						✓
Nega (2008)	✓	✓	✓	✓	✓	

Source **(Mahamid, 2014)**

2.13. Price Index and Cost Escalation

The construction price index informs us about the changes in the costs of industry sectors, which are a result of a combination of labor, materials, and equipment cost variables; it also helps contractors to identify trends, movements, and orientations in the construction market (NGUYEN, 2020). As the (NGUYEN, 2020) study has pointed out several critical factors that affect construction price indices, including basic loan interest rates, gross domestic product, consumer price index, exchange rates, total exports and imports, Vietnam's stock index, crude oil prices, the geographical location of the construction area, etc. all have their impact but the consumer price index is the most crucial factor among them. It is inevitable to determine the essential factors that affect the construction price index to boost the precise cost and overall investment calculation for buildings (NGUYEN, P. T., et. al, 2021). Price indices help track inflation the rate at which the overall level of prices rise and deflation the rate at which the overall level of prices fall (Bureau of Labor Statistics, 2021). The WPI which is considered for the calculation of escalation for civil engineering items comprises a basket of materials that contain approximately 91% of materials that are not directly related to the construction field in India (Chaphalkar, 2012). The construction price index plays a significant role in understanding the dynamics and trends of the construction industry as it accounts for various factors such as labor, materials, and equipment costs. By monitoring the construction price index, contractors can make better-informed decisions and ensure precise cost estimation and allocation for building projects (Chau, & Walker et. al, 2011). In the context of civil engineering projects in India, the WPI highlights the importance of considering construction-specific components to better estimate escalation costs. Ultimately, a comprehensive understanding of the construction price index allows contractors and policymakers to make effective decisions and optimize resource allocation within the industry.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

The study focuses on the causes of cost escalation and its impact level on commercial building projects in Adama town, Ethiopia. The researcher combined both descriptive and inferential research methods to thoroughly understand the subject matter. The researcher utilizing a quantitative research approach.This study employed both secondary and primary data collection methods to ensure reliability and validity. Secondary data was gathered through an extensive literature review, which helped form research objectives and questions. Primary data was collected using questionnaires, allowing for direct feedback from participants on their experiences and opinions.

3.2. Description of Study Area

Adama is a town in the central Oromia Region of Ethiopia. Located in the East Shewa Zone 99 km southeast of the capital, Addis Ababa, the city sits between the base of an escarpment to the west, and the Great Rift Valley to the east.

3.3. Research Type

The study focuses on the causes of cost escalation and its impact level on commercial building projects in Adama Town, of Ethiopia. The researcher in this thesis used descriptive research type.

3.4. Research Approach

Utilizing a quantitative research approach, the researchers conducted two surveys involving owners, consultants, and contractor engineers engaged in active commercial building projects.

The quantitative research approach enables researchers to establish statistical evidence on the strength of the relationship between variables. Further, the Quantitative research method can be used to determine the reliability and validity of the variable measurement. The study has been performed by quantitative research technique since it has established that quantitative research works by measuring and evaluating variables to get findings.

3.5. Research Design

To achieve the research objectives, the study framework involves five steps. The study identified factors causing cost escalation by using different data collection instruments such as literature reviews, and questionnaires, and by using other archival documents. Furthermore, these causes were serving as the independent variables of the predictive models of cost escalation in commercial building projects.

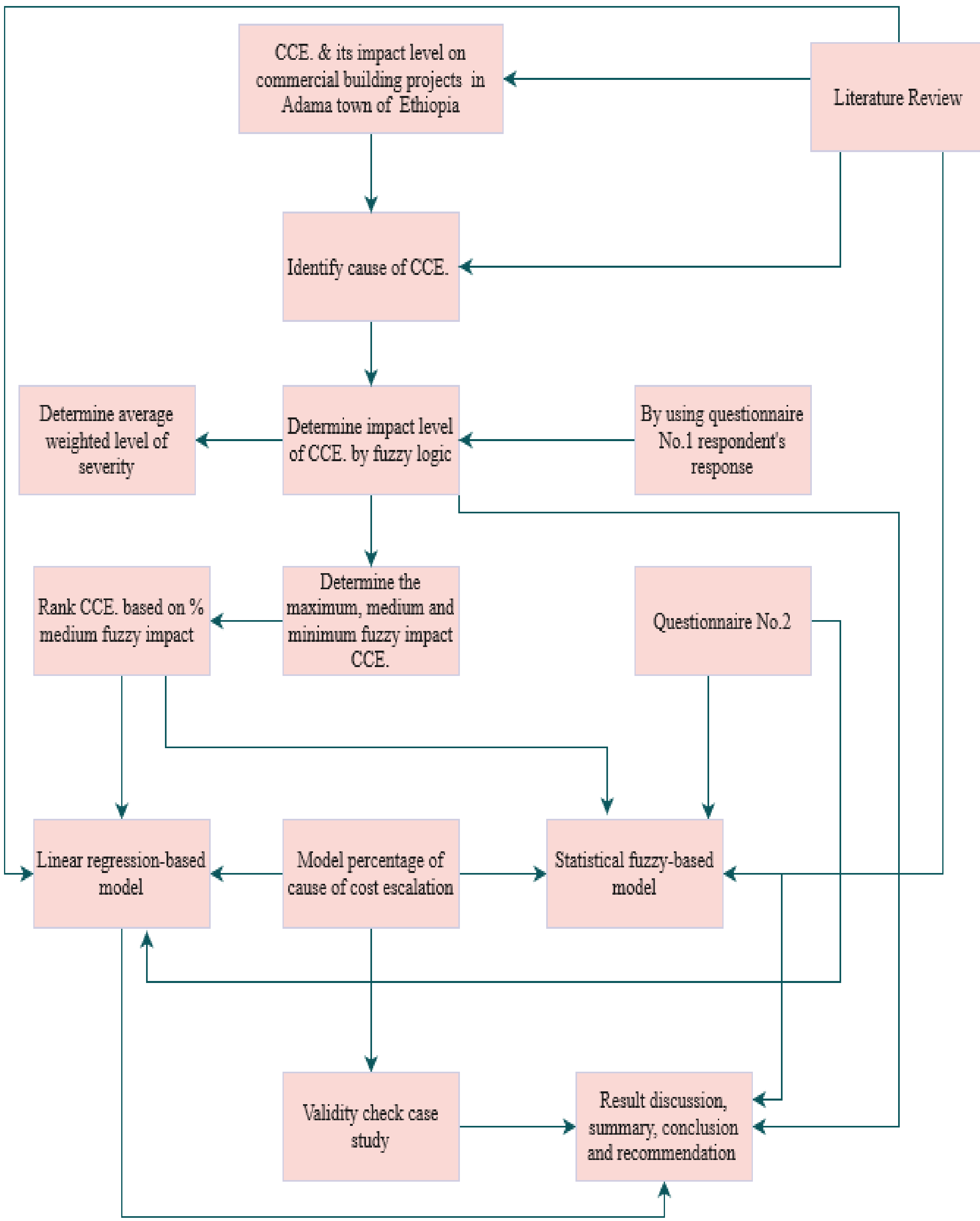

Figure 3. 1 Research design

3.5.1 Determining the impact level of the identified factors.

After the factors which may cause cost escalation in commercial building Projects were identified; questionnaire No.1 was designed to collect data about the impact level of the identified factors. In the designed questionnaire, the respondents have to choose one out of the four possible answers representing varying levels of impact on a scale of 1 to 4. A response of 1 the factor is a low impact, 2 the factor has a medium impact, 3 the factor has a high impact and 4 the factor has a very high impact.

Through the designed questionnaire, a survey was conducted to gather data from owners, consultants, contractors, and contracting companies and their representatives of commercial building projects. To give additional credibility to the findings of this survey, the participants would be asked about their length of experience and educational status. To evaluate the impact level of the identified factors, a triangle fuzzy membership function was used.

The steps followed to model factors causing cost escalation in commercial building projects were:

1. Determine the impact level of the identified factors using the triangular fuzzy membership function.
2. Determining the effectiveness degree of the identified factors using the triangular fuzzy membership function.
3. Determine the top critical factors causing cost escalation of commercial building projects.
4. Modeling the percentages of cost escalation of the commercial building using linear regression analysis method and statistical fuzzy theory.
5. Check the validity of the developed model.

To check the validity of the developed models for determining the C.E.P, a comparison between the linear regression model estimate and the statistical fuzzy model estimate has been conducted through the application of an Equation average error (El-Kholy, 2013)

$$\text{Average \% error} = \frac{|\text{Actual P.C.E} - \text{Estimated P.C.E}|}{\text{estimated P.C.E}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

- Determining the impact level of the identified factors based on the triangle fuzzy membership function is as follows:

1. Each factor was fuzzified according to its weighted degree of severity effect which is received from questionnaire responses;

2. Determining the minimum, medium, and maximum impact level of each factor;

3. Determining the membership of each effect according to its weighted degree of severity effect;

4. Forming a triangular membership function of each factor; and

5. Ranking the factors according to their medium impact level

*3.5.1.1 Steps to calculate determining the minimum, medium, and maximum impact level of each factor***.**

To calculate the minimum, medium, and maximum effectiveness value of each factor, it is possible to follow these steps according to Fuzzy Sets and Fuzzy Logic: Theory and Applications" (Yuan, 1995; Letcher. P., 2016).

1. Define the Membership Function: To start, define the Membership Function for each factor, the researcher defined the triangular Membership Function, Ensured the values that correspond to the minimum, medium, and maximum levels of each factor.

2. Define the weighted Degree of Severity (WDS): The weighted Degree of Severity (WDS) is the weight assigned to each factor to represent its impact on the overall system based on historical data, Ensured WDS values for all factors.

1. Calculate the Membership Value (MV):

For each factor, determine the membership values at each level of the membership function (e.g., minimum, medium, and maximum levels). To do this, use the membership function for the factor and plug in the corresponding values for minimum, medium, and maximum.

For example, let's consider a triangular membership function (A, B, C) for a factor X, where A, B, and C represent the minimum, medium, and maximum levels of that factor. To calculate the MV at each level:

i. MV min = Membership Function (X min)

ii. MV med = Membership Function (X med)

iii. MV max = Membership Function (X max)

2. Combine the Membership Values (MV) with the weighted Degree of Severity (WDS):

Using the calculated MV values, multiply the MV value for each level by the corresponding WDS value to acquire the weighted effectiveness values.

For example:

i. weighted impact level min = MV min * WDS

ii. Weighted impact level med = MV med * WDS

iii. Weighted impact level max = MV max * WDS

3.5.2 Regression Analysis.

Regression analysis is a quantitative research method that was used when the study involves modeling and analyzing several variables, where the relationship includes a dependent variable and one independent variable. In simple terms, regression analysis is a quantitative method used to test the nature of relationships between a dependent variable and one or more independent variables (Dudovskiy, 2013).

His basic form of regression models includes unknown parameters (β), independent variables (X), and the dependent variable (Y). The regression model specifies the relation of a dependent variable (Y) to a function combination of independent variables (X) and unknown parameters (β)

$$Y \approx f(X, \beta) \quad \ldots\ldots 3$$

Regression equation can be used to predict the values of ‘y’, if the value of ‘x’ is given, and both ‘y’ and ‘x’ are the two sets of measures of a sample size of ‘n’. The formula for the regression equation would be

$$Y = bx + a \quad \ldots\ldots 4$$

3.5.2.1. The steps followed to achieve the models by linear regression are as follows.

1. Determine the independent variables for the model.
2. Determine the dependent variable for the model.
3. Determine the factors affecting the dependent variable for the model on a yes-or-no basis for every project from the 45 surveyed projects.
4. Enter the independent variables and the dependent variables into Statistical Excel Software.

5. Determine the coefficients for the model by applying the Enter Linear Regression Variable Selection Method (ELRVSM).

The coefficients of determination (R^2) of the models of cost escalation percentage were calculated as follows: by using Ordinary Least Squares (OLS) method (Carl Friedrich Gauss & Adrien-Marie Legendre , 1833).

$$SSR = \Sigma(p_{value} - y_{\text{mean}})^2 \quad \ldots\ldots\ldots 5$$

Where

SSR=Regression Sum of Squares which measures the variance explained by the regression model:

p_value= are the predicted dependent variable values from the regression model,

y= mean is the mean of the observed dependent variable values.

$$SST = \Sigma(yi - y_{\text{mean}})^2 \quad \ldots\ldots\ldots 6$$

Where,

SST=Total Sum of Squares, which measures the total variance in the dependent variable:

yi= are the observed dependent variable values,

y =mean is the mean of the observed dependent variable values.

$$R^2 = \frac{SSR}{SST} \quad \ldots\ldots\ldots 7$$

3.5.3. Fuzzy Theory.

Let's consider fuzzy set A, A = {(x, μA(x))| x Є X} where μA(x) is called the membership function for the fuzzy set A. X is referred to as the universe of discourse. The membership function associates each element x Є X with a value in the interval [0, 1]. In fuzzy sets, each element is mapped to [0, 1] by the membership function. That is, μA: X €[0, 1], Where [0, 1] means real numbers between 0 and 1 (including 0, 1). Consequently, the fuzzy set is with a 'vague boundary set' compared with the crisp set (Klir. G. J., & Yuan. B., 1995).

μA (x) is the "membership function". The value of this function is between 0 and 1. This value represents the "degree of membership" (membership value) of element x in set A. The members of a fuzzy set are members to some degree, known as a membership grade or degree of membership. The membership grade is the degree of belonging to the fuzzy set. The larger the number the greater the degree of belonging.

In the fuzzy theory, fuzzy set A of universe X is defined by function μA(x) called the membership function of set A. This point had already been discussed.

$\mu A(x): X \rightarrow [0, 1]$, where $\mu A(x) = 1$ if x is totally in A;

$\mu A(x) = 0$ if x is not in A;

$0 < \mu A(x) < 1$ if x is partly in A.

This set allows a continuum of possible choices. For any element x of universe X, membership function μA(x) equals the degree to which x is an element of set A. This degree, a value between 0 and 1, represents the degree of membership.

3.5.3.1. Steps to achieve the Models based on the Statistical fuzzy approach.

To achieve the models of C.E.P based on the statistical fuzzy approach, seven steps have been presented as follows:

1. Fuzzify each cause of every model and determine its weighted degree of severity effect (S.Ei) and the corresponding membership function.

2. Extracting regression equation between each cause affecting cost escalation and C.E.P by using excels Software.

3. Determine the regression output ($R.O_i$) for every extracted equation for every model.

4. Determine the coefficient of determination (R-square) of the extracted equations.

5. Determine the weight (Wi) for every extracted equation by using the following formula (Neter, J. & Wasserman, W. et. al, 1996)

$$Wi = \frac{R\ square}{\sum_{i=1}^{n} R\ square} \qquad \text{.....8}$$

6. Determine the discrete universe (D.U) of C.E.P from Figures 4.4

7. Predict the value of C.E.P by using the following formula (James, G. & Tibshirani, R. et. al, 2013)

$$y = \frac{\sum(D.U)*[(SEi)*(ROi)*(Wi)]}{\sum[(SEi)*(ROi)*(Wi)]} \quad \ldots\ldots 9$$

where y* is the predictive value of cost escalation; D.U the discrete universe of cost escalation; S.Ei the severity effect of each cause of the model; R.Oi the regression output of each cause; and Wi the weight of the extracted equation.

Widely used methods in data analysis to create mathematical models based on a set of data points. These techniques can be applied in Excel and are useful for several purposes, including forecasting, optimization, and prediction.

3.6.Target Population

The study focuses on the cause of cost escalation and its impact level on commercial building projects in Adama town. The targeted populations of the study were active commercial building projects in Adama town. According to the data which was received from Adama town construction authority there are a total number of 50 active commercial building sites in the city. There is a need to use the representative sample from the general population of the study, as a sampling frame for the study.

3.7. Source of Data

To ensure the reliability and validity of the study, the researcher employed a combination of both secondary and primary data collection methods. Secondary data was gathered from various sources such as academic journals, books, and reputable online databases, which provided a solid foundation for the study and helped the researcher in this thesis; gain a deep understanding of the research topic. This extensive literature review allowed the researcher to identify existing theories, findings, and gaps in the knowledge, thus helping me to shape the research objectives and questions. A literature review has been also used to identify the driving force of cost escalation which is studied by previous researchers, while primary data was collected using questionnaires, allowing for direct feedback from participants on their experiences and opinions. These combined methods allowed for a comprehensive and rigorous research process.

3.8. Sampling for Target Population

The targeted survey respondents were construction stakeholders who directly participated in the daily activity of the projects such as contractors, consultants, owners, and their representatives. Hence it is costly and time-bound to take all the targeted population there is a need to take a sample. So the sample size for this study was calculated by using Yamane's formula (1967).

$$sample\ size = \frac{N}{(1+Ne^2)} \quad \ldots\ldots 1$$

$$n_0 = \frac{50}{1+50*0.05^2} = 44.44 = 45$$

Where:

Assume confidence level=95%

N=50

- n_0= sample size
- e is the desired level of precision (i.e. the margin of error),
- p is the (estimated) proportion of the population which has the attribute in question,
- q Is 1 – p.

So the data was collected from the targeted survey respondents who directly participated in the daily activity on the projects such as contractors, consultants, owners, and their representatives on active commercial building projects sites in Adama town by distributing questionnaires to these respondents.

3.9. Sampling for Target Respondents

A field survey using purposive respondent selection based on the participants' length of experience, educational background, position, and stake in the projects was conducted. So the data was collected from the targeted survey respondents who directly participated in the daily activity on the projects such as contractors, consultants, owners, and their representatives on active commercial building projects sites in Adama town by distributing questionnaires to these respondents

3.10. Data Collection Tool

In conducting the study, a combination of questionnaires and a literature review was utilized to ensure comprehensiveness and rigor in the research process. The use of questionnaires enabled the collection of valuable data directly from the participants, allowing for the analysis of their perspectives, experiences, and opinions on the subject matter. By administering questionnaires, it was possible to gather first-hand information, which helped in establishing the authenticity and accuracy of the research findings. On the other hand, a literature review was conducted to analyze and synthesize the wealth of information available from previous studies, academic publications, and reputable sources related to the research topic. This process allowed for the examination of existing theories, trends, and research gaps, which ultimately informed the research questions, objectives, and methodologies employed in the study. By combining the empirical data obtained from questionnaires with the evidence gathered from the literature review, the study was able to draw reliable and robust conclusions that contributed to the existing body of knowledge on the topic. A literature review has been used to identify the driving force of cost escalation which is studied by previous researchers.

To achieve the objective, a pilot test was conducted for the reviewed literature to ascertain the validity and reliability of the causes identified in research studies. A questionnaire survey was then developed and distributed among various participants in the construction sector, including project managers, consultants, owners, and contractors, to gather their views and opinions on cost escalation drivers.

Following the collection and analysis of data obtained through the questionnaire survey, 29 causes of cost escalation were identified as significant in the context of Adama Town's construction projects. These causes were grouped into various categories based on their nature, for a more structured and systematic understanding of the escalation drivers. Some of the key categories and related causes include Project-related factors, market-related factors, contractual factors, regulatory factors, environmental factors, communication, and human-related factors.

3.11. Data Analysis Tools

Excel soft ware was used for data analysis and interprets data collected and processed by different data collection and analysis methods. The researcher utilized Microsoft Excel, spreadsheet software, to organize, analyze, and present the research data. Excel was used to create tables and systematically organize the data, making it easier to read and understand. The researcher also created visual representations of the data, such as charts and graphs, to better convey trends or patterns. Additionally, the various mathematical and statistical functions available in Excel to perform calculations, derive insights, and develop equations related to the research were used. Overall, Excel was a crucial tool in assisting the researcher to better comprehend and communicate the results of this research. Regression analysis and fuzzy modeling were

3.12. Reliability and Validity of the Research.

The title is clear and concise, accurately reflecting the main focus of the research paper. The current title, "Driving Force of cost escalation and its Impact Level on commercial buildings in Adama Town of Ethiopia", is quite clear about the subject of the study. The research was validated by using criterion validity and inter-rater reliability methods. In this case, the research question seems relevant as it aims to identify the factors that drive cost escalation and assess their impact on commercial buildings, which could be useful for policymakers, developers, and investors in the real estate sector. A reliable and valid research paper should employ appropriate data collection methods for its research question. This paper used questionnaires and a literature review as data collection techniques. Using questionnaires provide primary data from respondents directly involved in the construction and development industry, while a literature review offers secondary data to support and enrich the findings.

3.13. Research Ethical Consideration

The research on "Driving force of cost escalation and its impact level on active commercial building projects in Adama Town of Ethiopia" has considered the ethical considerations to ensure the study was conducted responsibly and respectfully.

Participants in the study, such as building owners, contractors, or local government officials, were informed about the purpose of the research, the methodology, expected outcomes, and potential risks involved. They voluntarily agreed to participate and have the option to withdraw from the research at any time. The personal information of the participants and any sensitive data collected was kept confidential and not disclosed to any third party without the participant's consent.

Anonymize the data so that individuals or specific buildings were not identified. Respect the privacy of the participants by not collecting any information that was not essential for the study or by using intrusive methods to gather data. Researchers minimized any potential risks or harm that could arise from participating in the study. This could include financial, emotional, or reputational harm. Ensured that research data was collected, analyzed, and reported with honesty and accuracy. Avoid manipulating or fabricating data to achieve desired results or to support preconceived conclusions. The research process and findings have been transparent and unbiased. A researcher was acknowledging any preconceptions or potential sources of bias and strives to remain neutral and objective throughout the study. Ensured that the research was conducted following local laws, regulations, and guidelines related to construction, cost management, environmental concerns, and any other relevant aspects. Obtained approval from a relevant institutional review board or ethics committee and an advisor before proceeding with the research.

CHAPTER FOUR: DATA ANALYSIS AND DISCUSSION

4.1. Introduction

In these parts, the researchers analyze and discuss the data collected from the respondents. The analysis and discussion include respondent number, percentage of data distributed to each party, their length of experience, and educational background. In addition to this, the major section of the paper was discussed. The data collected from the literature review and questionnaire survey were analyzed.

4.2. Summary of Number and Percentage of Questioners Distributed and Collected

A literature review has been used to identify the driving force of cost escalation which is studied by previous researchers. Through the designed questionnaire survey has been conducted to gather data from owners, and consultants of active commercial building projects in Adama town. A total of 15 owners, 20 consultants, and 45 contractor engineers have participated in the survey. The designation of the respondents to the distributed questionnaire is 21 project managers, 24 site engineers, 20 office engineers, and 15 owners on questionnaire No. 1. Furthermore, to give additional credibility to the findings of this survey, the participants have been asked about their length of experience. A total of 53.15 percent of the respondents have experience of more than 3 years, whereas 28.82 percent have experience of more than 10 years. Besides, the designed questionnaire No.1, a survey has been conducted to gather data from owners, and consultants of active commercial building projects in Adama town. Second questionnaire was used to gather the nominated percentages of cost escalation and was given to 45 contractual stakeholders in the Adama town.

The sections of second questionnaire

The first section of the questionnaire asks two questions about the percentage of cost escalation. The reply has been assigned to determining the percentage of cost-escalation of commercial building projects in Adama towns in the first question. The second question requests the respondent to indicate, on a yes-or-no basis, whether any of the top 10 reasons impacting the schedule overrun influence this percentage.

For second questionnaire a total of 10 owners, 15 consultants, and 20 contractor engineers have participated in the survey. The designation of the respondents to the distributed questionnaire is 18 project managers, 2 site engineers, 15 office engineers, and 10 owners on questionnaire No. 1. Furthermore, to give additional credibility to the findings of this survey, the participants have been asked about their length of experience. A total of 43.15 percent of the respondents have experience of more than 3 years, whereas 58.85 percent have experience of more than 10 years. After determining the questionnaire objectives and designing its sections, copies of the questionnaire have been distributed to the participants by conducting a personal interview with them. After two weeks of following up with the participants, a total of 45 questionnaires have been returned. The returned questionnaires have been reviewed by the researchers, combined, and entered into computer spreadsheets for the process of analysis.

Table 4. 1 Number and percentage of questioners distributed and collected

S.N	Respondents		Questionnaire distributed		Questionnaire returned		Percentage of response
1	Stakeholders	Project manager	N.o	%	N.o	%	%
	Contractor	✓	21	26.25	18	22.5	26.47
	Owner		-	-	-	-	-
	Consultant		-	-	-	-	-
2		Consultant					
	Owner	✓	24	30	19	23.75	27.94
	Contractor		-	-	-	-	-
3		Site engineer					
	Contractor	✓	20	25	20	25	29.41
	Owner		-	-	-	-	-
4	Owner		15	18.75	11	13.75	16.17
Total			80	100	68	85	100

The overall response rate for the survey was 68(85%) out of 80 questionnaires distributed. The response rate in the survey was 38(55.88%) from contractor side, 19(27.94%) from consultant, and 11(16.17%) from owner side.

4.3 Educational Background of the Respondents

Education backgrounds are the degrees, diplomas, certificates, professional titles, and other credentials that a person has earned through full-time, part-time, or self-study, whether the credentials were granted domestically, or abroad by educational authorities, specialized examining bodies, or professional bodies. The successful completion of a course of study or training program is consequently a prerequisite for the attainment of an educational qualification. Most of the respondents from the parties 47 (58.75%) of the respondents have a first degree, 17(21.25%) have a master's degree, and 16(20%) have a diploma.

4.4 Fuzzification of Cause of Cost Escalation Identified from Literature

For instance, Cce.1 is calculated as follows: "change orders of scope that were not covered by original contract" has been fuzzified by the researcher as follows. The responses related to this factor from the respondents to Questionnaire No. 1 are 11 for very high impact, 17 for high impact, 20 for medium impact, and 6 for low impact. Accordingly, the weighted degrees of severity effect are: [(11× 4)/(4 × 45)]= 0.244, [(17× 3)/(4 × 45)] 0.283, [(20× 2)/(4 ×4 5)] = 0.222 and [(6× 1)/(4 × 45)] = 0.033 for (4/4) =1, (3/4) =0.75, (2/4) = 0.50 and (1/4) = 0.25 memberships, respectively.

Table 4. 2 Fuzzified cause of cost escalation

Cause of cost escalation	Low	Medium	High	V.high
Change orders of scope	0.085	0.128	0.45	0.228
Large Size of the project	0.086	0.5	0.172	0.143
Inflation	0.035	0	0.428	1
Length of time to complete the project	0.036	0.243	0.45	0.45
The incompleteness of engineering design	0.178	0.242	0.107	0.143
Complexities of administration hierarchy	0.178	0.314	0.278	0
The inexperience of administration personnel	0.257	0.171	0.15	0.1423
Poor contract management	0.071	0.328	0.45	0.171
Improper planning	0.064	0.114	0.643	0.2
Inaccurate estimating	0.057	0.143	0.535	0.486
Project location	0.185	0.357	0.193	0
Site condition	0.25	0.185	0.257	0

Suspension and strike of work	0.085	0.257	0.364	0.229
Poor coordination on site	0.15	0.357	0.171	0.057
Local government pressure	0.214	0.242	0.171	0.028
National political instability	0.114	0.257	0.45	0.142
Personnel inexperience in contract work	0.221	0.257	0.235	0
Material supply shortage	0.007	0.442	0.45	0.2
Transportation cost	0.057	0.1	0.771	0.257
Regulatory and permitting cost	0.157	0.185	0.407	0.057
Exchange rate of fluctuation	0.035	0.114	0.557	0.6
Change in interest rate	0.15	0.171	0.364	0.142
Demand and supply factors	0.107	0.243	0.407	0.257
Labor shortage and wage increase	0.057	0.357	0.471	0.142
Increase in demand	0.014	0.428	0.514	0.1142
Productivity of labor and machinery	0.121	0.414	0.171	0.057
Tax	0.128	0.328	0.236	0.171
Government policy	0.107	0.2	0.257	0.542
Market trend	0	0.128	0.171	1.228

4.5 Computing Weighted Level of Severity for Causes on Cost Escalation

Table 4. 3 Weighted levels of severity of the impact of causes on cost escalation.

Membership function		0.125	0.25	0.375	0.5	0.625	0.75	0.875	1
s.n	causes of cost escalation	weighted level of severity impact on cost escalation							
1	Change orders of scope	0.042	0.085	0.107	0.128	0.178	0.228	0.339	0.45
2	Large Size of the project	0.042	0.085	0.114	0.143	0.157	0.171	0.293	0.5
3	Inflation	0	0	0.018	0.036	0.232	0.428	0.714	1
4	Length of time to complete Project	0.018	0.036	0.139	0.243	0.346	0.45	0.45	0.45
5	Incompleteness of design	0.054	0.107	0.125	0.143	0.178	0.193	0.211	0.243
6	Complexities of administration hierarchy	0	0	0.089	0.178	0.228	0.278	0.296	0.315
7	Inexperience of administration	0.071	0.143	0.146	0.15	0.161	0.171	0.214	0.257

	Personnel								
8	Poor contract management	0.035	0.071	0.121	0.172	0.2	0.328	0.389	0.45
9	Improper planning	0.057	0.064	0.089	0.114	0.132	0.2	0.421	0.642
10	Inaccurate estimating	0.028	0.057	0.1	0.142	0.314	0.485	0.510	0.536
11	Project location	0	0	0.093	0.186	0.189	0.193	0.275	0.357
12	Site condition	0	0	0.093	0.1857	0.218	0.25	0.253	0.257
13	Suspension and strike of work	0.043	0.086	0.157	0.228	0.243	0.257	0.310	0.364
14	Poor coordination on site	0.028	0.057	0.104	0.15	0.161	0.171	0.264	0.357
15	Local government pressure	0.014	0.028	0.1	0.171	0.193	0.214	0.228	0.243
16	National political instability	0.057	0.114	0.128	0.114	0.2	0.257	0.353	0.45
17	Personnel inexperience on contract work	0	0	0.110	0.221	0.229	0.235	0.246	0.257
18	Resource Supply shortage	0.004	0.007	0.103	0.2	0.321	0.443	0.446	0.45
19	Transportation cost	0.028	0.057	0.078	0.1	0.178	0.257	0.514	0.771
20	Regulatory and permitting cost	0.028	0.057	0.107	0.157	0.171	0.186	0.296	0.407
21	Exchange rate of fluctuation	0.018	0.035	0.075	0.114	0.335	0.557	0.578	0.6
22	Change in interest rate	0.071	0.143	0.146	0.15	0.160	0.171	0.267	0.364
23	Demand and supply factors	0.053	0.107	0.175	0.244	0.25	0.257	0.332	0.407
24	Labor shortage and wage increase	0.028	0.057	0.1	0.143	0.25	0.357	0.414	0.471
25	Increase in demand	0.007	0.014	0.064	0.114	0.271	0.428	0.471	0.514
26	Productivity of labor and Machinery	0.028	0.057	0.121	0.114	0.146	0.171	0.292	0.414
27	Tax	0.064	0.128	0.15	0.171	0.203	0.235	0.282	0.328
28	Government policy	0.053	0.107	0.153	0.2	0.228	0.257	0.4	0.542
29	Market trend	0	0	0.064	0.128	0.15	0.171	0.7	1.228

The researchers add the entries to determine the weighted degree of severity for 0.125, 0.375, 0.625, and 0.875 memberships, (0.0+0.085)/2 = 0.042, (0.085+0.128)/2 = 0.106, (0.128+0.45)/2 = 0.289 and (0.45 +0.228)/2 = 0.339, respectively. Now, the weighted degree of severity effect for this cause is [0.042, 0.085, 0.106, 0.012, 0.228, 0.289, 0.339, 0.45] for memberships [0.125, 0.25, 0.375, 0.50, 0.625, 0.75, 0.875, 1.0], respectively. Likewise, the weighted degree of severity effect for the other causes of cost escalation has been calculated as illustrated for Fs.1 as shown in Table 4.4.

4.6. Determining the Minimum, Medium, and Maximum Impact value of each Cause

Calculate the minimum, medium, and maximum effectiveness value of each factor, according to Fuzzy Sets and Fuzzy Logic: (George J. Kweir & Bo Yuan, 1995): The table of minimum, medium, and maximum impact value of each cause is presented in appendix C.

4.7. Ranking Cause of Cost Escalation According to Medium Impact Level

Tables 4.4 show the causes of cost escalation, which have been arranged in descending order according to their medium fuzzy impact value. Then, the causes are ranked according to their medium fuzzy impact value such that the cause receives the highest medium fuzzy impact value and is assigned a rank equal to 1.

This table shows that “National Political instability” has been chosen as the most influencing factor causing the cost escalation of commercial building projects in Adama town. Political instability can significantly impact the cost escalation of the construction industry. Construction projects usually require long-term planning, significant financial investments, and a stable environment to ensure their timely and efficient execution. The construction industry is highly dependent on public and private investment, a skilled workforce, and the availability of raw materials. Political instability can negatively affect these essential elements, resulting in increased costs and delays in project completion. A country with insufficient peace and political instability will place a heavy strain on the task, which in turn results in low-quality work and a lack of attention, having a considerable negative impact on the project. In addition, the respondents to the questionnaire believe that “Resource supply shortage by the contractor or owner” is the second influencing factor causing cost escalation of commercial building projects. Previous kinds of literature (Haseeb, M., & Bibi, A et. al , 2016) explained the importance of these factors and their impacts on the project cost. According to Haseeb, A., and Odeyinka, Resource supply shortages by the contractor or owner can have significant impacts on cost escalation in the construction industry. A lack of sufficient resources, such as labor, materials, and equipment, can lead to project delays, increased costs, and reduced quality of work.

Furthermore, “inaccurate cost estimation” has been ranked as the third factor causing cost escalation of commercial building Projects. Inaccurate cost estimates may require additional budget allocations, causing financial stress on project owners, contractors, and other stakeholders (Flyvbjerg, 2002).

Table 4. 4 Ascending order of cause of cost escalation based on medium fuzzy effect.

By using steps metioned in methodology and its presented in appendix C

Rank Cce.	Ascending order of cause of cost escalation	%medium impact level
1	National security	0.362
2	Material supply shortage	0.356
3	Inaccurate estimation	0.35
4	Inflation	0.321
5	Market trend	0.318
6	Delaying the length of time to complete the project	0.303
7	Suspension and strike of work	0.293
8	Improper planning	0.290
9	Transportation cost	0.281
10	Exchange rate of fluctuation	0.262
11	scope change order	0.262
12	Increase in demand	0.237
13	The inexperience of administration personnel	0.234
14	Poor contract management	0.221
15	Labor wage increase	0.218
16	Productivity of labor and machinery	0.203
17	Poor coordination on site	0.203
18	Government policy	0.2
19	Personnel inexperience	0.196
20	Site condition	0.190
21	Regulatory and permitting cost	0.187
22	Tax	0.178
23	Local government pressure	0.168
24	Project location	0.159
25	Demand and supply factors	0.156
26	Complexities of administration structure	0.146
27	Change in interest rate	0.140

28	Size of project	0.137

Budget overruns also result in delays to project completion and negatively affect the overall cost of construction projects (Creedy, 2010).

Inaccurate cost estimation can have significant implications on cost escalation in the construction industry, resulting in budget overruns, project delays, disputes, and loss of trust. All stakeholders need to prioritize accurate and reliable cost estimation methods to improve project management and mitigate the risks associated with cost escalation. Inflation" has been also ranked as the fourth factor causing cost escalation in commercial building projects in Adama town.

One of the most direct effects of inflation on the construction industry is an increase in the cost of raw materials. As inflation drives up the prices of key construction materials such as steel, cement, and timber, the overall cost of construction projects increases (Bouazzaoui, 2020). This increase in material costs can lead to project delays or even cancellations, as developers may face budgetary constraints or difficulties acquiring financing for their projects due to increased costs associated with inflation (Lo, & Lauder et. al, 2022) In addition to the cost of raw materials, inflation also impacts the cost of labor in the construction industry. As the cost of living increases due to inflation, workers demand higher wages. With wage inflation, construction companies must pay more for labor, resulting in higher overall construction costs (Bunni, 2003).

Furthermore, inflation affects the cost of financing for construction projects. As inflation rates increase, there is a corresponding rise in interest rates, as central banks attempt to control inflation. High-interest rates can lead to an increase in the cost of borrowing for construction projects, further escalating construction costs (Laryea, Challenges and opportunities facing contractors in Ghana., 2010). Taking everything into account inflation has a pronounced impact on cost escalation in the construction industry through its effect on raw material prices, labor costs, financing expenses, and contract disputes. These factors can lead to increased construction costs and project delays, ultimately impacting the profitability of the industry and the overall economy.

4.8. Modeling Percentages of Cost Escalation

To model the percentages of cost escalation of commercial building projects in Adama town through the application of linear regression method and statistical fuzzy theory, three steps have been designed to clearly illustrate the modeling methodology which has been followed to achieve the proposed models beginning from the determination of the independent and dependent variables, passing through the modeling process and ending with checking the validity of the developed models. The following sections will explain briefly the designed steps for the modeling process.

4.8.1. Independent variables of the proposed models.

In the current study, the obtained top 10 factors causing cost escalation as shown in Tables I and II have been identified as the independent variables of the proposed models to measure their impact on the percentage cost escalation of the constructing commercial building projects in Adama town.

4.8.2. Dependent variables of the proposed models.

Predicting the percentages of the cost escalation of the constructing Commercial building projects in Adama city is considered the main dependent variable of the developed models. Therefore, these percentages have been considered as the dependent variables of the proposed models. Additionally, questionnaire No. 2 was used to gather the nominated percentages of cost escalation and was given to 45 contractual stakeholders in the Adama town.

The first section of the questionnaire asks two questions about the percentage of cost growth. The reply has been assigned to determining the percentage of cost-escalation of commercial building projects in Adama town in the first question. The second question, on the other hand, requests the respondent to indicate, on a yes-or-no basis, whether any of the top 10 reasons impacting the schedule overrun influence this percentage.

4.8.3. Linear regression-based models

The 35 projects that Ire surveyed provided the data for the linear regression-based models of the created statistical formula, which Ire then validated using the remaining 10 projects. Additionally, statistical Excel software was used to calculate the coefficients of the linear equations. The steps that followed were used to achieve the cost escalation percentage models:

1. Identify each model's independent variables:

The top 10 elements impacting cost escalation in the C.E.P. model

2. Identify the dependent variable for each model for each of the 35 projects included in the survey:

   • For the cost escalation percentage model

3. Determine the factors affecting the dependent variable for every model on a yes-or-no basis for every project from the 35 surveyed projects.

4. Enter the independent variables and the dependent variable for every model for every project from the 35 surveyed projects into excel Software.

(5) Determine the coefficients for every model by applying the Enter Linear Regression Variable Selection Method (ELRVSM).

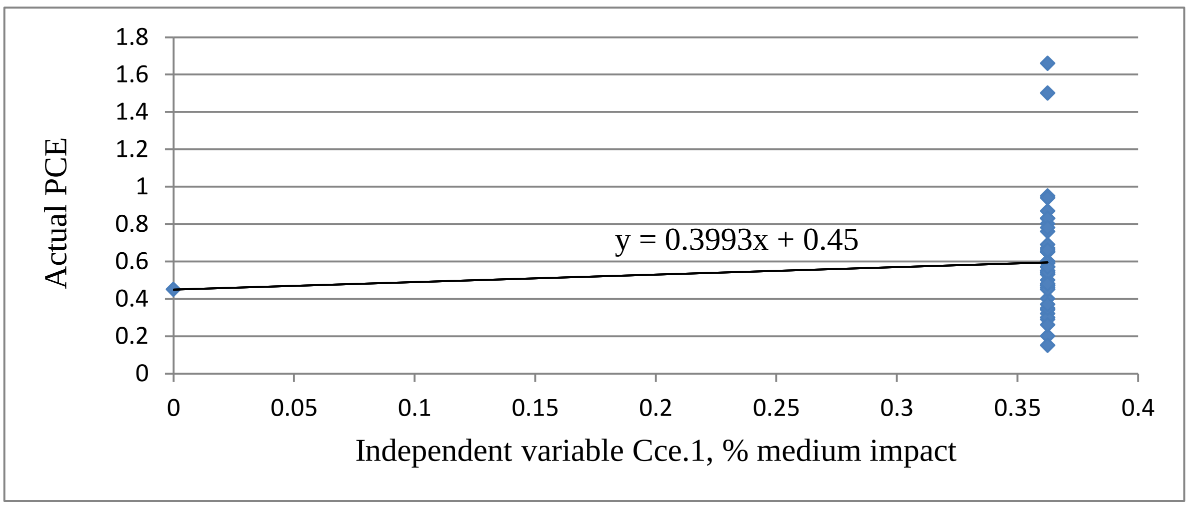

Figure 4. 1 Dependent vs. independent variables

The coefficient of independent variables is a measure of the strength and direction of the relationship between an independent variable (x) and a dependent variable (y) in a statistical model, such as regression analysis. In this context, a coefficient of 0.3993 means that for every one-unit change in the independent variable, the dependent variable is expected to change by 0.3993 units, holding all other independent variables constant. Since the coefficient is positive (0.3993), this indicates a positive relationship between the independent variable and the dependent variable. In other words, as the independent variable increases, the dependent variable is also expected to increase.

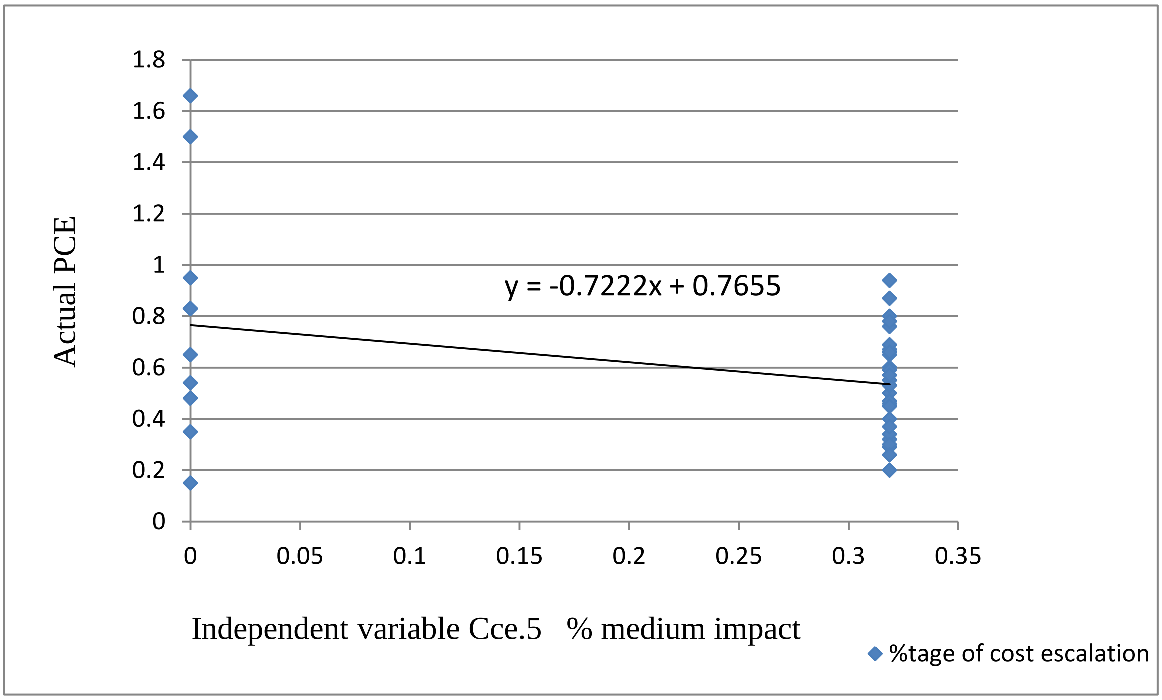

Figure 4. 2 Percentage of cost escalation vs. Independent variable Cce.

The magnitude of the negative coefficient indicates how much the dependent variable (Y) is expected to change for a one-unit increase in the independent variable (X). The negative coefficient for X is -0.722, then for every 1-unit increase in X, Y is expected to decrease by 0. 722 units, holding all other factors constant. In addition to this an R-square value of 0.1219 means that 12.19% of the variability in the dependent variable can be explained by the independent variables in the model. This suggests a relatively weak relationship between the variables in the model, and 87.81% of the variability remains unexplained by the model. Generally, higher R-square values (closer to 1) indicate a better fit between the predicted values and the actual data points.

Here is a summary of the models that the applied ELRVSM produced:

0.393 (Cce.1) + 0.237(Cce.2) +0.23(Cce.3) -0.472(Cce.4) -0.722(Cce.5) + 0.649(Cce.6) + 0.176(Cce.7) + 0.666(Cce.8) + 0.759(Cce.9) – 0.102(Cce.10)……………………………10

The coefficients of determination (R^2) of the models of cost escalation percentage are calculated by using Ordinary Least Squares (OLS) method (Carl Friedrich Gauss & Adrien-Marie Legendre , 1833). By using equation (7)

$$R^2 = \frac{SSR}{SST}$$

$SSR = \Sigma(p_{value} - y_{mean})^2$ equation (5)

Where

SSR=Regression Sum of Squares which measures the variance explained by the regression model:

p_value= are the predicted dependent variable values from the regression model,

y= mean is the mean of the observed dependent variable values.

$SST = \Sigma(yi - y_{mean})^2$ equation(6)

Where,

SST=Total Sum of Squares, which measures the total variance in the dependent variable:

yi= are the observed dependent variable values,

y =mean is the mean of the observed dependent variable values.

$R^2 = \frac{SSR}{SST}$ equation (7)

Table 4.5 predicted dependent variable values from the regression model and observed dependent variable values.

Yi	0.262	0.28125	0	0	0	0.318	0.321	0.35	0.356	0.362
p-value	7.78 E-10	7.51E-07	6.41 E-05	1.77 E-10	6.45 E-12	0.000662	0.000662	2.7E-05	0.002655	1.26 E-08

$$y = \frac{\sum yi}{10} = 0.225313$$

$$SST=\sum(yi-y)^2= 0.547446$$

$$SSR = \Sigma(p\_value- y\_mean)^2=0.50583$$

$$R^2 = \frac{SSR}{SST} = 0.923982 \approx 0.924$$

The coefficient of determination (R-square) of the models of cost escalation percentage is 0.924. This indicates that the model of C.E.P can explain 92.4 percent of the variability in the data which is an excellent indicator of the model's expected performance. On the other hand, (Ahmed Ebrahim , 2016) model has an R-squared value of 0.790, meaning that his model can explain 79% of the variability in the data. Although both models show excellent performance in terms of explained variability, there is a difference of 13.4 percentage points between the two R-squared values (92.4% - 79%). This suggests that the first model might be superior in predictive performance compared to Ahmed Ebrahim's model, as it explains a larger portion of the variability in the data. (Elhag, 2005) Also found that the model had an adjusted R-squared value of 0.61, indicating that these predictors explained 61% of the variation in cost overruns.

4.8.4. Statistical fuzzy-based model.

The two criteria that form the foundation of the statistically fuzzy-developed models are used to forecast the percentages of cost growth in Adama City commercial building projects. The first criterion is a trapezoidal membership function which has been adopted to determine the discrete universe of C.E.P as shown in Figure 4.4, while the other criterion is based on a separate regression equation between each cause affecting the cost escalation, and C.E.P of commercial building projects.

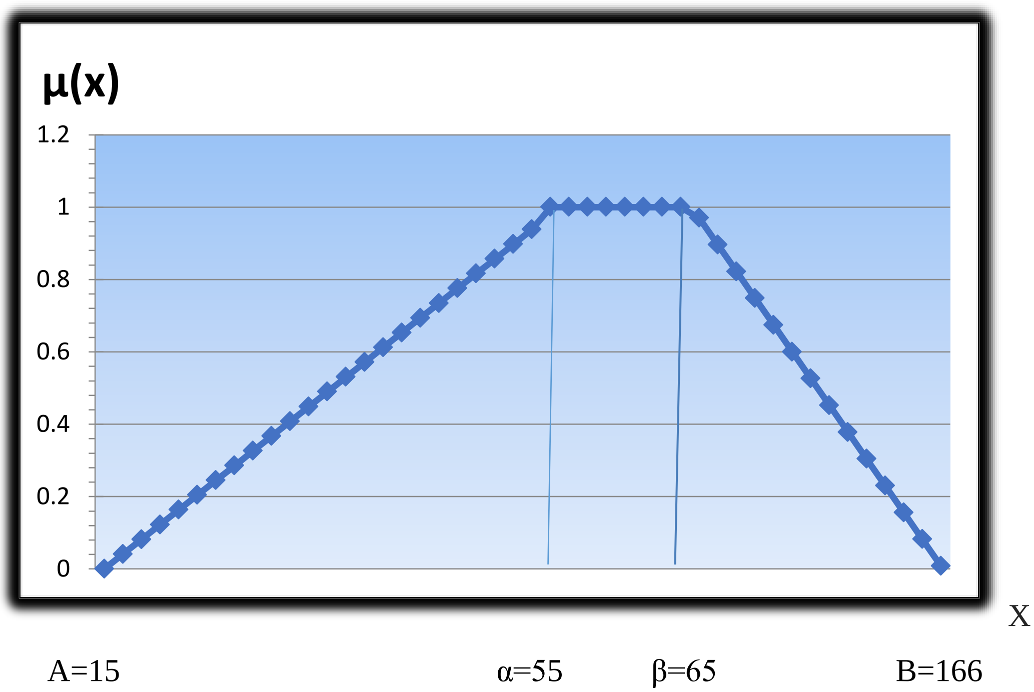

Figure 4. 3 Membership function of cost escalation percentage

The shown figures represent the minimum value (A), the maximum value (B), less than average (α), and larger than average (β) of the most common cost escalation percentage of the commercial building projects in Adama town. This trapezoidal membership function has been purposed to represent the discrete universe of S C.E.P as shown in Figure 4.4. For instance, the discrete universe of cost escalation percentage corresponding to membership function 0.50 can be deduced from Figure 4.4 as follows: D.U at 0.25 membership function [(0.55-0.15) ×0.5+0.15] = 0.25 or [(1.66−0.65) ×0.250+0.65] = 0.9025. Accordingly, the discrete universe for cost escalation percentage is [0.25, 0.35, 0.45, 0.5, 1.66, 1.4075, 1.155, 0.9025] corresponding to membership functions [0.25, 0.50, 0.75, 1, 1, 0.75, 0.50, 0.25]. Furthermore, it must be noted that a membership value equal to 1 has been repeated because the most likely interval of cost escalation percentage ranges between 55 and 65 percent, i.e. two values of 55 and 65 percent correspond to a membership 1.

Table 4.6 Weighted levels of severity impact of cost escalation vs. Membership function.

Membership function →		0.125	0.25	0.375	0.5	0.625	0.75	0.875	1
S.N	causes of cost escalation	weighted level of severity impact of cost escalation							
Cce.1	National political instability	0.057	0.114	0.128	0.114	0.2	0.257	0.353	0.45
Cce.2	Resource supply shortage	0.004	0.007	0.103	0.2	0.321	0.443	0.446	0.45
Cce.3	inaccurate estimating	0.028	0.057	0.1	0.142	0.314	0.485	0.510	0.536
Cce.4	Inflation	0	0	0.018	0.036	0.232	0.428	0.714	1
Cce.5	market trend	0	0	0.064	0.128	0.15	0.171	0.7	1.228
Cce.6	length of time to complete project	0.018	0.036	0.139	0.243	0.346	0.45	0.45	0.45
Cce.7	suspension and strike of work	0.043	0.086	0.157	0.228	0.243	0.257	0.310	0.364
Cce.8	improper planning	0.057	0.064	0.089	0.114	0.132	0.2	0.421	0.642
Cce.9	transportation cost	0.028	0.057	0.078	0.1	0.178	0.257	0.514	0.771
Cce.10	exchange rate fluctuation	0.018	0.035	0.075	0.114	0.335	0.557	0.578	0.6

The Severity Impact Table is a tool used to assess and quantify the potential impact of various events or risks on a project or operation. It is particularly useful for comparing the potential effects of different situations and making informed decisions based on data.

Each event, such as national political instability, resource supply shortage, or inaccurate estimation, can have a varying level of severity impact ranging from 0.125 (least severe) to 1 (most severe). The "weighted" aspect of the table signifies that each level of severity is assigned a numerical weight that represents its significance or intensity. This means that a higher weight indicates a more severe potential impact on the project or operation.

By assigning these numerical weights to each level of severity, the table can help stakeholders compare the potential consequences of different events or risks more easily. This can be particularly important when prioritizing resource allocation or deciding on project contingencies. Moreover, the numerical weights also make it possible to combine the potential impacts of multiple events or calculate the overall risk exposure of a project or operation.

The Severity Impact Table is a valuable tool for assessing and quantifying the potential impacts of various situations on a project or operation, allowing stakeholders to make informed, data-driven decisions. It helps to compare the severity of different events by assigning numerical weights to each level of severity, resulting in a clearer understanding of potential risks and their implications.

Table 4. 7 Regression output and weight of extracted equations of cost escalation causes.

Causes	Regression equation(RE)	R-square	Occurrence of C.C.E	RO_i=RE* Occurr	W_i
Cce.1	0.273941	0.25	1	0.273941	0.109
Cce.2	0.434785	0.21	1	0.434785	0.092
Cce.3	0.33794	0.294	1	0.33794	0.129
Cce.4	0.191669	0.353	1	0.191669	0.155
Cce.5	0.440384	0.12	1	0.440384	0.053
Cce.6	0.4912926	0.253	0	0	0.111
Cce.7	0.612926	0.253	1	0.6912926	0.111
Cce.8	0.269816	0.275	0	0	0.121
Cce.9	0.202493	0.156	1	0.202493	0.068
Cce.10	0.25991	0.116	1	0.25991	0.051

The above table presents a comprehensive analysis of the relationship between various causes and their impact on different projects. It includes a regression equation, R square value, and the occurrence of each cause occurring in the studied projects. The regression equation serves as a mathematical model to predict the dependent variable based on the independent variable. This helps in understanding the extent and nature of the association between the causal factors and the project performance

The information provided in the table, along with the derived metrics such as the regression output and the weight of R square, presents a comprehensive evaluation of cause factors on project performance. This analysis can aid project managers and stakeholders in understanding the key causes impacting projects' success and adopting effective strategies to address and overcome the.

Table 4. 8 Occurrence of causes (independent variables) on each project

S.N	C.E.P	Occurrence of causes (independent variables) on each project									
		Cce.1	Cce.2	Cce.3	Cce.4	Cce.5	Cce.6	Cce.7	Cce.8	Cce.9	Cce.10
p1	50	1	1	1	1	1	0	0	0	1	1
p2	65	1	1	1	1	1	1	1	1	1	1
p3	45	1	1	1	1	1	1	1	0	1	1
p4	20	1	0	1	1	1	0	0	1	0	1
p5	57	1	1	1	1	1	1	1	1	1	1
p6	32	1	1	0	0	1	0	0	0	1	1
p7	45	0	1	1	1	1	1	1	0	1	1
p8	67	1	1	1	1	1	1	0	1	1	1
p9	53	1	0	1	1	1	0	1	1	1	1
p10	55	1	1	1	1	1	1	1	1	1	0

Table 4.8 shows the occurrence of the independent variables on the percentage of cost escalation on each project for which questioner no. 1 is distributed. As it was tried to be determined by the researcher above, the percentage of cost escalation is a dependent variable. This occurrence is represented by 0 and 1, which implies that 0 is the factor that does not contribute to the recorded percentage of respondents to bring the cost escalation to another level. 1 implies that the cause of cost escalation is contributing to the existence of a percentage that happened on the respondent’s project. If the respondent says yes or 1 the value of the selected response is replaced by the value calculated in the medium fuzzy effect.

Table 4. 9 Summation of SEi×ROi×Wi

Causes	Membership function							
	0.125	0.25	0.375	0.5	0.675	0.75	0.875	1
Cce.1	0.00304	0.00609	0.00684	0.00609	0.01069	0.01374	0.01887	0.02405
Cce.2	0.00028	0.00049	0.00734	0.01425	0.02288	0.03157	0.03178	0.03207
Cce.3	6.94E-06	1.41E-05	2.48E-05	3.52E-05	7.79E-05	0.00012	0.00012	0.00013
Cce.4	0	0	0.00014	0.00028	0.00184	0.00339	0.00566	0.00793
Cce.5	0	0	0.00264	0.00528	0.00618	0.00705	0.02887	0.05066
Cce.6	0	0	0	0	0	0	0	0
Cce.7	0	0	0	0	0	0	0	0
Cce.8	0	0	0	0	0	0	0	0
Cce.9	0.00050	0.00056	0.00078	0.00100	0.00116	0.00177	0.00372	0.00568
Cce.10	2.1E-07	4.27E-07	5.84E-07	7.48E-07	1.33E-06	1.92E-06	3.85E-06	5.77E-06
∑S.Ei × R.Oi × Wi	0.003844	0.007175	0.017781	0.026961	0.042848	0.057656	0.089058	0.120544

This table shows the summation of three parameters of the denominator of the predicted value "y" to be calculated. SEi is determined in the table from the responses gained from the respondents, while ROi and Wi were taken from data analyzed through regression analysis by Excel software.

$$\sum[\sum SEi \times ROi \times Wi] = 0.003844 + 0.007175 + 0.017781 + 0.026961 + 0.042848 + 0.057656 + 0.089058 + 0.120544 = 0.366867$$

Table 4. 10 Determination of summation of ∑[D.U×∑(SEi×ROi×Wi)]

Determination of summation of ∑[D.U×∑(SEi×ROi×Wi)]								
∑S.Ei × R.Oi × Wi	3.84×10^{-3}	7.17×10^{-3}	1.78×10^{-2}	2.7×10^{-2}	4.28×10^{-2}	5.77×10^{-2}	8.91×10^{-2}	1.21×10^{-1}
D.U	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025

In data analysis, a discrete universe refers to a data set or sample space in which the values or possible outcomes are separated and distinct, often in the form of integers or categories. This is in contrast to a continuous universe, where data points can take any value within a range, often represented by real numbers.

By using Equation 9

$(D.U) * [(\sum SEi) * (ROi) * (Wi)]$ =3.84×10^{-3}×0.25+7.17×10^{-3}×0.35+1.78×10^{-2}×0.45+ 2.7×10^{-2} ×0.5+4.28×10^{-2}×1.66+5.77×10^{-2}×1.401+8.91×10^{-2}×1.155+1.21×10^{-1}×0.9025

=0.388

$$y = \frac{\sum(D.U) * [\sum(SEi) * (ROi) * (Wi)]}{\sum[(SEi) * (ROi) * (Wi)]}$$

$$y = \frac{0.388}{0.366} = 1.061891$$

So y=106.2 percent, thus, the expected percentage of cost escalation is 106.2% percent.

4.9. Validity Check Case Study

To check the validity of the developed models for determining the C.E.P, a comparison between the linear regression model estimate and the statistical fuzzy model estimate has been conducted through the application of an Equation average error (El-Kholy, 2013)

By using equation (2)

$$\text{Average \% error} = \frac{|\text{ Actual P.C.E} - \text{Estimated P.C.E }|}{\text{estimated P.C.E}} \times 100$$

Where P. C. E actual is the actual percentage of cost escalation; P.C.E estimated the estimated percentage of cost escalation which results from the application of linear regression model estimate and the statistical fuzzy model estimate.

Table 4. 11 Occurrence replaced by medium fuzzy impact

Cce.1	Cce.2	Cce.3	Cce.4	Cce.5	Cce.6	Cce.7	Cce.8	Cce.9	Cce.10	Y value
Linear regression model coefficient										
0.392	0.2377	0.2303	-0.471	-0.72	0.6495	0.1762	0.666	0.7589	-0.102	
	Occurrence replaced by medium fuzzy impact									
0.362	0.356	0.35	0.321	0.318	0.303	0.293	0.290	0.281	0.262	0.554
0.362	0.356	0.35	0	0.318	0.303	0.293	0.290	0.281	0.262	0.706
0.362	0.356	0.35	0	0.318	0	0	0.290	0.281	0.262	0.457
0.362	0.356	0.35	0	0.318	0	0.293	0.290	0.281	0.262	0.509
0.362	0.356	0.35	0.321	0.318	0.303	0.293	0.290	0.281	0.262	0.445
0.362	0.356	0.35	0.321	0.318	0.303	0.293	0.290	0.281	0.262	0.554
0	0.356	0.35	0.321	0.318	0.303	0.293	0.290	0.281	0.262	0.412
0.362	0.356	0.35	0.321	0.318	0.303	0.293	0.290	0.281	0.262	0.554
0.362	0.356	0.35	0.321	0.318	0	0.293	0.290	0.281	0.262	0.357
0.362	0.356	0.35	0.321	0.318	0.303	0	0.290	0.281	0.262	0.502

In the given context, equation (2) is employed to determine the estimated percentage of cost escalation (represented as the y-value) based on the occurrence and medium fuzzy impact values found in Table 4.4. The occurrence value indicates the likelihood or frequency of a specific influencing factor affecting the project, while the medium fuzzy impact value assesses the significance or magnitude of that particular factor. The table demonstrates a range of possible combinations between these values to create different estimations for cost escalation.

The estimated percentage of cost escalation is an important aspect of project management, as it helps decision-makers understand the potential financial implications concerning various factors that can influence a project's overall success. By using this information, it is possible to develop an action plan to minimize the undesirable effects of cost escalation on a project. To further refine and scrutinize these estimates, the value of error between the estimated and actual percentage of cost escalation is deduced. This process involves comparing the values computed using equation(2) and the actual values observed in real projects. The error analysis helps determine the accuracy of the model and identifies any inconsistencies or discrepancies in the estimation process.

Ultimately, the objective of using these combinations and deriving the error value is to improve the understanding of cost escalation and its influences on a project. By doing so, project managers and stakeholders can develop more accurate budgeting and financial strategies, enhancing project performance and reducing the likelihood of cost overruns. Additionally, a thorough analysis of such errors can lead to potential improvements in the underlying model or equation, allowing for more precise estimations and better decision-making in the future.

Table 4. 12 Occurrences replaced by medium fuzzy effect value of cause of cost escalation on every project that was selected for validity check.

Cause	Occurrences were replaced by medium fuzzy effect value of cause cost escalation on every project that was selected for validity check.								
Cce.1	0.362	0.362	0.362	0.362	0.362	0.362	0	0.362	0.362	0.362
Cce.2	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356
Cce.3	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Cce.4	0.321	0	0	0	0.321	0.321	0.321	0.321	0.321	0.321
Cce.5	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318
Cce.6	0.303	0.303	0	0	0.303	0.303	0.303	0.303	0	0.303
Cce.7	0.293	0.293	0	0.293	0.293	0.293	0.293	0.293	0.293	0.293
Cce.8	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290
Cce.9	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281	0.281
Cce.10	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262

According to Table 4.12, Occurrences that were replaced by a medium fuzzy effect value represent the causes of cost escalation in various projects. These causes were identified and analyzed across all the projects that were specifically chosen to check the accuracy and reliability of the results. By replacing the occurrences with a medium fuzzy effect value, the researchers were able to assign a numerical value to each cause. This allowed them to compare and prioritize the different causes contributing to cost escalation, thereby facilitating a better understanding of the factors that need to be addressed to minimize cost overruns. Additionally, the utilization of the medium fuzzy effect value ensured that the researchers considered the inherent uncertainty and vagueness associated with the estimation of project costs and the impact of various factors on cost escalation.

Table 4. 13 Regression output for every project selected to check the validity

S.N	ROiP1	ROiP2	ROiP3	ROiP4	ROiP5	ROiP6	ROiP7	ROiP8	ROiP9	ROiP10
Cce.1	0.099	0.099	0.099	0.099	0.099	0.099	0	0.099	0.099	0.099
Cce. 2	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
Cce. 3	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
Cce. 4	0.061	0	0	0	0.061	0.061	0.061	0.061	0.061	0.061
Cce. 5	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
Cce. 6	0.276	0.276	0	0	0.276	0.276	0.276	0.276	0	0.276
Cce. 7	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268
Cce. 8	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
Cce. 9	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
Cce.10	0.0015	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0015

The regression output for every project selected aims to evaluate the validity of the regression equation by examining the occurrence of causes of cost escalation in commercial building projects in Adama. The regression equation is a mathematical tool used to identify the relationship between variables and find the best possible predictions. By analyzing these projects, experts can determine if the applied regression equation is effective in highlighting and predicting the factors that lead to issues in commercial building projects.

In this context, the regression output will be applied to several projects selected to represent Adama commercial building projects. The results will help identify the most common causes of project challenges, including political instability, supply shortage, and other construction-related issues. This, in turn, allows stakeholders to focus on the most critical issues and implement strategies to minimize their impact on the commercial construction sector.

This in-depth analysis could help improve project efficiency, resource allocation, and overall performance in the construction industry of Adama. Consequently, the findings and recommendations drawn from these regression outputs will be essential for developers, contractors, and policymakers to better understand the contributing factors to project success and failure. This critical knowledge will enable them to create reliable plans and strategies, resulting in the sustainable growth of Adama commercial building projects.

Table 4. 14 The summation of SEi and ROiP1 product (∑SEi×ROiP1)

Projects	The summation of SEi and ROiP1 product (∑SEi×ROiP1)							
Cce.1	0.001	0.002	0.002	0.002	0.003	0.004	0.006	0.008
Cce.2	0.0001	0.00017	0.002	0.005	0.008	0.011	0.011	0.011
Cce.3	2.43E-06	4.94721E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	4.43E-05	
Cce.4	0	0	4.59E-05	9.19E-05	0.000592	0.001092	0.001822	0.002552
Cce.5	0	0	0.0008	0.0016	0.0019	0.0022	0.0092	0.0161
Cce.6	0.0009	0.00196	0.007	0.013	0.018	0.024	0.024	0.024
Cce.7	0.002	0.0045	0.008	0.012	0.012	0.013	0.016	0.019
Cce.8	0.0002	0.00029	0.0004	0.0005	0.0006	0.0009	0.001	0.002
Cce.9	6.97E-05	0.00014	0.0001	0.0002	0.0004	0.0006	0.0012	0.0019
Cce.10	3.54E-08	6.87478E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
∑SEi×ROiP1×Wi	0.0048	0.009350	0.022	0.035	0.047	0.059	0.073	0.087
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.902
[D.U×(∑SEi×ROiP1×Wi)]	0.0012	0.003272624	0.010128	0.017602	0.078766	0.083189	0.084852	0.079092

By using Equation 9

$$y = \frac{\sum(D.U) * [\sum(SEi) * (ROin) * (Wi)]}{\sum[(SEi) * (ROin) * (Wi)]}$$

Where

ROi_n is regression out of each cause of cost escalation and each project. By using this formula

$\sum$SEi×ROiP1×Wi=

0.004801+0.009350353+0.022508+0.035205+0.04745+0.059378+0.073465+0.087636=0.339

$\sum$[D.U×($\sum$SEi×ROiP1×Wi)]=

0.0012+0.003272624+0.010128+0.017602+0.078766+0.083189+0.084852+0.079092

$$y = \frac{\sum[\mathrm{D.U} \times (\sum \mathrm{SEi} \times \mathrm{ROiP1} \times \mathrm{Wi})]}{\sum \mathrm{SEi} \times \mathrm{ROiP1} \times \mathrm{Wi}} = \frac{0.358102704}{0.339793091} = 1.053 = 105.3\%$$

By using the above procedures the estimated percentage of the cause of cost escalation by the Statistical fuzzy model is determined for all ten projects selected for validity check.

Table 4. 15 Linear regression model and Statistical fuzzy model error.

The actual percentage of cost escalation	Linear regression model	Statistical fuzzy model	Linear regression model error	Statistical fuzzy model error
45	55.416	105.3885	18.797	57.301
166	70.602	105.2514	135.119	57.718
54	45.739	103.0388	18.062	47.593
76	50.914	101.2339	49.27	24.926
66	44.507	105.3885	48.291	37.375
59	55.416	105.3885	6.467	44.017
78	41.206	111.4721	8.9291	30.027
37	55.416	105.3885	33.233	64.892
48	35.728	103.3089	34.347	53.537
57	50.24	105.3885	13.454	45.914
		Average error%	44.63	46.33

The validity of the developed models depending on the used sample size of the questionnaire has been checked to show the prediction accuracy of the developed models, and it has been noted that the linear regression-based models can accurately assess the expected cost escalation of any future commercial building projects in Adama town at a level of confidence of 56.37 percent, while statistical fuzzy-based models can predict the cost escalation of commercial building projects in Adama town at a level of confidence of 53.67 percent.

Therefore, the study suggested using linear regression-based models rather than statistical fuzzy-based models in predicting the cost escalation of commercial building projects in the Adama town.

This research has demonstrated the effectiveness of linear regression-based and statistical fuzzy-based models in predicting the cost escalation of commercial building projects in Adama town. The developed models were validated using varied sample sizes of the questionnaire, and their prediction accuracy was assessed. Linear regression-based models exhibited a higher level of confidence at 56.37 percent compared to statistical fuzzy-based models at 53.67 percent. This indicates that the linear regression-based models are more accurate in predicting the cost escalation for future commercial building projects in Adama town. However, it is essential to acknowledge the limitations of these models in terms of their confidence levels, as further improvements and refinements could potentially be made to enhance their prediction accuracy. Overall, the research findings provide valuable insights for project managers, real estate developers, and stakeholders in the construction industry in Adama town, enabling them to make better-informed decisions regarding the cost and profitability of their commercial building projects using the developed prediction models.

(Ahmed Ebrahim , 2016) found that to show the prediction accuracy of the developed models and it has been noted that the linear regression-based models can accurately assess in expected schedule delay and cost escalation of any future highway projects at the level of confidence 46.32 and 69.58 percent, respectively, while statistical fuzzy-based models can predict schedule delay and cost escalation of highway construction projects at the level of confidence 42.32 and 59.63 percent, respectively.

In comparing the results of the two studies, it can be observed that the linear regression-based models displayed a higher level of confidence and prediction accuracy in both cases. In the first study, which focused on commercial building projects in Adama town, the linear regression-based models showed a 56.37 percent confidence level, while the statistical fuzzy-based models had a 53.67 percent confidence level. Similarly, in the second study regarding highway construction projects in Egypt, linear regression-based models demonstrated a 46.32 percent confidence level in predicting schedule delays and a 69.58 percent confidence level in predicting cost escalations, as opposed to the statistical fuzzy-based models with 42.32 percent and 59.63 percent confidence levels, respectively.

From these findings, it can be concluded that linear regression-based models are more accurate and reliable when predicting schedule delays and cost escalations in both commercial building projects and highway construction projects than statistical fuzzy-based models. Therefore, the use of linear regression-based models is recommended for project managers, real estate developers, and other stakeholders in the construction industry who wish to make well-informed decisions regarding their projects' costs and profitability. However, it is important to recognize the limitations of these models in terms of their confidence levels and explore further improvements and refinements to enhance their prediction accuracy.

However, it is important to recognize the limitations of this study, particularly the knowledge gap observed among respondents during the data collection process, which may have influenced the model's accuracy. Future research should focus on addressing this concern by using larger sample sizes, providing additional training or resources to respondents to ensure their full understanding of the questionnaire, and incorporating other variables or methodologies to enhance the prediction accuracy of the developed models. Despite these limitations, this research serves as a valuable contribution to the field of cost management and prediction in the construction industry. The linear regression-based and statistical fuzzy-based models offer a promising starting point for the development of more sophisticated predictive tools that can ultimately lead to better cost management practices and successful completion of commercial building projects in Adama town and beyond.

4.10. Summary

The causes of cost escalation of commercial building projects in Adama town are discussed in a field survey. The current study adopted a fuzzy triangular function to identify the impact level of the factors influencing cost escalation from the contractors’, consultants’, and owners’ views. Through a detailed literature review, 29 causes of cost escalation were identified. The field survey included 15 owners, 20 consultants, and 45 contractor’s engineers for questionnaire No.1, while to design questionnaire No.2 a total of 10 owners, 15 consultants, and 20 contractor’s engineers participated in the survey. The results are in line with many previous studies in that the problem of cost escalation is a phenomenon in the construction of commercial building projects.

In summary, the main reasons for cost escalation in Adama town commercial building projects are national political instability, resource supply shortage, inaccurate estimating, inflation, market trend, project duration, work suspension and strikes, improper planning, transportation costs, and exchange rate fluctuations. The study has developed linear regression-based models and statistical fuzzy-based models to predict cost escalation in these projects. The linear regression-based models were found to be more accurate in predicting cost escalation, with a confidence level of 56.37%, compared to the statistical fuzzy-based models, which had a confidence level of 53.67%. Thus, the study recommends using linear regression-based models for predicting cost escalation in commercial building projects in Adama town.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The top ten serious reasons for cost escalation in Adama town commercial building projects with the order of impact level are National political instability, resource supply shortage, Inaccurate estimating, Inflation, market trend, length of time to complete the project, suspension, and strike of work, improper planning, transportation cost, and exchange rate fluctuation. While scope change orders, increase in demand, the inexperience of administration personnel, poor contract management, labor wage increase, the productivity of labor and machinery, poor coordination on site, government policy, Personnel inexperience, site condition, regulatory and permitting cost, Tax, are found to be the major causes of cost escalation in commercial building projects in Adama town. Furthermore, the study presents models for predicting the percentages of cost escalation for commercial building projects in the Adama Town. The developed models are based on the linear regression analysis method and a statistical fuzzy approach. The top 10 causes of cost escalation have been incorporated into the models as independent variables.

The validity of the developed models depending on the used sample size of the questionnaire has been checked to show the prediction accuracy of the developed models, and it has been noted that the linear regression-based models can accurately assess the expected cost escalation of any future commercial building projects in Adama town at a level of confidence of 56.37 percent, while statistical fuzzy-based models can predict the cost escalation of commercial building projects in Adama town at a level of confidence of 53.67 percent. Therefore, the study suggested using linear regression-based models rather than statistical fuzzy-based models in predicting the cost escalation of commercial building projects in the Adama Town.

5.2. Recommendation

Based on the findings of this study, the researcher recommends the following actions for stakeholders involved in commercial building projects in Adama town:

1. Stakeholders should prioritize the identification and mitigation of potential risks associated with the top 10 causes of cost escalation to minimize any negative impact on project budgets.

2. Robust and accurate estimating and planning methods should be developed and implemented to manage the risks associated with cost escalation factors such as inaccurate estimating, market trends, and transportation costs.

3. Improving contract management, personnel experience, and on-site coordination can help control cost escalation due to poor management practices. Organizations should invest in training for project managers and staff to enhance their capabilities in handling commercial building projects.

4. Establishing a clear and thorough change management process can help manage scope change orders and their impact on project costs.

5. Promote better communication and collaboration among project stakeholders to ensure proper alignment of expectations, sharing of information, and effective decision-making.

6. Develop strong relationships with local regulatory bodies as well as national institutions to actively address any policy or permitting issues that may affect project costs.

7. The linear regression-based model demonstrated higher prediction accuracy and should be adopted by stakeholders to estimate the cost escalation of future commercial building projects in the Adama town.

In conclusion, by proactively addressing the identified cost escalation factors and implementing the recommended actions, stakeholders can contribute towards better control over commercial building, and project costs in Adama town. Furthermore, the use of the linear regression-based model for predicting cost escalation can help manage uncertainties and improve decision-making related to project budgets.

5.3. Directions for Future Researchers

1. Expanding the scope and geographical area: Future research can expand the scope of this study to other types of construction projects, such as residential, industrial, and infrastructure projects. Additionally, it would be beneficial to explore cost escalation factors in commercial building projects in other cities and regions in Ethiopia and compare the findings with the current study.

2. Longitudinal analysis: Analyzing data over a longer period will enable future researchers to investigate how changes in the political and economic environment affect cost escalation in commercial building projects. This would provide valuable insights into the stability and robustness of the developed prediction models under different scenarios.

3. Comparing different prediction methods: Further research could compare the performance of other prediction methods, such as artificial neural networks, and decision tree models, with the current linear regression and statistical fuzzy-based models. This would help in identifying the most accurate and suitable technique for predicting cost escalation in various contexts and project types.

4. Exploring mitigation strategies: Researchers can investigate specific mitigation strategies that are effective in reducing cost escalation in commercial building projects. Quantifying the impact of these interventions on project budgets could be valuable for stakeholders in making informed decisions and adopting effective risk management practices.

5. Investigate the impact of emerging technologies: Emerging technologies such as Building Information Modeling (BIM) and smart materials have the potential to influence cost escalation in commercial building projects. Future research can evaluate the impact of these technologies on various cost escalation factors and the effectiveness of adopting these innovations in managing and controlling project costs.

6. Multi-criteria decision-making approaches: Future studies can explore multi-criteria decision-making approaches for prioritizing the most influential and critical cost escalation factors and devising strategies to mitigate or manage them optimally. This would enable stakeholders to prioritize their efforts and resources efficiently.

7. Incorporating the perspectives of various stakeholders: While this study primarily focused on project managers and construction professionals, and owners it would be beneficial to incorporate the perspectives of other stakeholders in future research. This would provide a more comprehensive understanding of the factors affecting cost escalation in commercial building projects and enable the development of more holistic solutions to manage cost escalation effectively.

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APPENDIX

Appendix A: Questionnaires

Letter of data Requisition for Questioner N.o 1

School of Civil Engineering and Architecture, specialization in Construction Engineering and Management.

Adama

Phone number: 0953696645

Email address: www.yobekani19@gmail.com

Date 26/04/2023 G.c

Dear/D.r/Pof.

I'm writing to collect data about the causes of price escalation on construction building projects and its effectiveness degree in Adama town. I'm Yobsen Bekele, MSc. Student at Adama Science and Technology University in the School of Civil Engineering and Architecture; specialization in Construction Engineering and Management. On my behalf, I'm formally requesting permission to access the aforementioned data. I plan to use this data to identify the cause of price escalation and its effectiveness degree on construction building projects and finally model the price escalation. Aside from the researcher, I aim to share the data with my advisor.

I am grateful for your consideration of my request.

Sincerely

Yobsen Bekele

Section I: Respondents' Professional & educational background assessment

This section surveys the professional background of the respondents.

1. Area of operation of the company you are working in;

Consultant Contractor owner regulatory/supervisors

2. Your highest level of education (in Civil Engineering or Construction Technology Management or other related Engineering fields of study)

Certificate/Diploma Bachelor Degree Master's Degree PhD

3. Your current position in the company;

Contract Administrator Contract Engineer or Claims Expert

Procurement Team Leader Project Engineer

If other (specify)

4. Years of experience working in public and commercial building Construction projects;

> 10 - <15 (From 10 to 15 years) > 7 - <10 (From 7 to 10 years)

>5 - <7 (From 5 to 7 years) >3 - <5 (From 3 to 5 years)

If other (specify)

5. Overall professional experience in a construction project;

> 10 - <15 (From 10 to 15 years) > 7 - <10 (From 7 to 10 years)

>5 - <7 (From 5 to 7 years) >3 - <5 (From 3 to 5 years)

If other (specify)

Section II: what do you think is the price escalation percentage of building projects in Adama City?

Section III: what is the impact level of the listed cause of price escalation on construction building projects?

S. N	Causes of price escalation on a construction project	Impact Level of causes on the project to suffer price escalation in Adama city.				
		Low	medium	High	Very high	Remark
1	Change orders to the scope that was not covered by the original contract					
2	Large Size of the project					
3	Inflation					
4	Length of time to complete the project					
5	The incompleteness of engineering design					
6	Complexities of administrative hierarchy					
7	The inexperience of administrative personnel					
8	Poor contract management					
9	Improper planning					
10	Inaccurate estimating					
11	Project location					
12	Site conditions					
13	Suspension of works and Strikes					
14	Poor coordination on site					
15	Local government pressure					
16	Political discontinuity and transportation problems					
17	Personnel experience in contract works					
18	Supply shortage					
19	Transportation cost					

20	Regulatory and permitting cost					
21	Fluctuation exchange rate					
22	Change in interest rate					
23	Demand and supply factors					
24	Labor shortage and wage increase					
25	Increase in demand					
26	Productivity of labor and machinery					
27	Tax					
28	Government policy					
29	Market trend					

Questioner N.o 2

1. What is the percentage of the cost escalation in your project_______________________
2. Identify which factors influencing your project

S.N	Do these factors have an impact on this Percentage	Yes	No
1	National political instability		
2	Resource supply shortage		
3	inaccurate estimating		
4	Inflation		
5	market trend		
6	length of time to complete the project		
7	suspension and strike of work		
8	improper planning		
9	transportation cost		
10	exchange rate fluctuation		

Appendix B: Raw data collected by Questionnaire No. 1

Table 1. Raw data collected by Questionnaire No. 1

cause of cost escalation	Low	medium	high	very high
change orders of scope	15	21	19	13
size of project	14	37	10	7
Inflation	5	14	34	15
length of time to complete the project	7	19	23	19
the incompleteness of engineering design	18	20	16	14
complexities of administration structure	37	18	6	7
the inexperience of administration personnel	18	14	19	17
poor contract management	3	37	25	3
improper planning	7	10	27	24

inaccurate estimating	5	12	27	24
project location	26	25	11	6
site condition	37	15	14	2
suspension and strike of work	12	13	22	21
poor coordination on site	13	17	20	18
local government pressure	32	19	10	7
political discontinuity and transportation problem	8	10	23	27
personnel inexperience in contract work	32	20	13	3
Material supply shortage	3	13	27	25
transportation cost	10	9	28	21
regulatory and permitting cost	24	21	15	8
exchange rate of fluctuation	7	20	18	23
change in interest rate	22	14	19	13
demand and supply factors	17	9	31	11
labor shortage and wage increase	10	27	24	7
increase in demand	4	32	26	6
productivity of labor and machinery	13	21	20	14
Tax	20	25	13	10
government policy	16	16	14	22
market trend	3	13	27	25

Apendix C

The minimum, medium, and maximum impact values of each cause cost escalation

Table 1

Cause of cost escalation	Min. IV	Med. IV	Max. IV
Change orders of scope	0.005	0.064	0.45
The large size of the project	0.005	0.071	0.5
Inflation	0	0.018	1
Length of time to complete the project	0.002	0.121	0.45
The incompleteness of engineering design	0.006	0.071	0.242
Complexities of administration hierarchy	0	0.089	0.314
The inexperience of administration personnel	0.008	0.075	0.257
Poor contract management	0.004	0.086	0.45
Improper planning	0.007	0.057	0.643
Inaccurate estimating	0.003	0.071	0.535
Project location	0	0.093	0.357
Site condition	0	0.093	0.257
Suspension and strike of work	0.005	0.114	0.364
Poor coordination on site	0.003	0.075	0.357
Local government pressure	0.002	0.086	0.243
National political instability	0.007	0.0571	0.45
Personnel inexperience in contract work	0	0.111	0.257
Material supply shortage	0.00	0.1	0.45
Transportation cost	0.004	0.05	0.771
Regulatory and permitting cost	0.003	0.078	0.407
Exchange rate of fluctuation	0.002	0.057	0.6
Change in interest rate	0.009	0.075	0.364
Labor shortage and wage increase	0.004	0.071	0.471
Increase in demand	0.001	0.057	0.514
Productivity of labor and machinery	0.003	0.057	0.414
Tax	0.008	0.085	0.328

Government policy	0.006	0.1	0.543
Market trend	0	0.064	1.228

Appendix D: Occurrences replaced by medium fuzzy effect value

Table 1. Occurrences replaced by medium fuzzy effect value of cause cost escalation on every project that was selected for validity check and actual percentage of cost escalation.

Cce10	Cce 9	Cce 8	Cce 7	Cce 6	Cce 5	Cce 4	Cce 3	Cce 2	Cce 1	P.C.E
0.262	0.2812	0	0	0	0.3187	0.3218	0.3	0.3562	0.362	0.5
0.262	0.2812	0.2906	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.65
0.262	0.2812	0	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.45
0.262	0	0.2906	0	0	0.3187	0.3218	0.3	0.3562	0.362	0.2
0.262	0.2812	0.2906	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.57
0.262	0.2812	0	0	0	0.3187	0.3218	0	0.3562	0.362	0.32
0.262	0.2812	0	0.2937	0.3031	0.3187	0	0	0	0	0.45
0.262	0.2812	0.2906	0	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.67
0	0.2812	0.290	0.2937	0	0.3187	0.3218	0.3	0	0.362	0.53
0.262	0.2812	0.2906	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.55
0.262	0.2812	0.2906	0.2937	0	0.3187	0.3218	0	0.3562	0.362	0.34
0	0.2812	0	0.2937	0.3031	0.3187	0	0	0.3562	0.362	0.55
0.262	0.2812	0	0	0	0.3187	0.3218	0.3	0	0.362	0.29
0.262	0	0	0.2937	0	0.3187	0.3218	0.3	0.3562	0.362	0.3
0	0.2812	0	0.2937	0.3031	0.3187	0.3218	0.3	0	0.362	0.47
0.262	0.2812	0.2906	0	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.46
0.262	0.2812	0.2906	0.2937	0	0	0	0.3	0.3562	0.362	0.95
0.262	0.2812	0.2906	0.2937	0.3031	0	0.3218	0.3	0.3562	0.362	0.65
0	0.2812	0.2906	0	0.3031	0	0.3218	0.3	0	0.362	0.48
0	0.2812	0.2906	0	0.3031	0.3187	0	0	0	0.362	0.87
0.262	0.2812	0	0.2937	0.3031	0.3187	0.3218	0	0.3562	0.362	0.6
0.262	0	0.2906	0.2937	0.3031	0.3187	0	0.3	0.3562	0.362	0.68
0	0.2812	0.2906	0.2937	0.3031	0.3187	0	0.3	0	0.362	0.59

0.262	0.2812	0.2906	0.2937	0	0.3187	0	0.3	0.3562	0.362	0.4
0.262	0	0.2906	0	0.3031	0	0.3218	0.3	0.3562	0.362	0.35
0	0.2812	0.2906	0	0	0.3187	0.3218	0.3	0.3562	0.362	0.26
0.262	0.2812	0.2906	0	0.3031	0.3187	0.3218	0.3	0	0.362	0.53
0.262	0.2812	0.2906	0	0	0	0.3218	0.3	0.3562	0.362	0.15
0.262	0.2812	0.2906	0	0.3031	0.3187	0	0.3	0.3562	0.362	0.57
0	0.2812	0.2906	0	0.3031	0	0.3218	0.3	0.3562	0.362	0.83
0.262	0	0.2906	0.2937	0.3031	0.3187	0	0.3	0.3562	0.362	0.47
0.262	0.2812	0.2906	0.2937	0.3031	0	0.3218	0.3	0.3562	0.362	1.5
0.262	0.2812	0.2906	0.2937	0	0.3187	0.3218	0.3	0.3562	0.362	0.8
0	0.2812	0.290	0.2937	0	0	0.3218	0.3	0.3562	0.362	0.83
0.262	0.2812	0.2906	0	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.94
0.262	0.2812	0.2906	0	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.45
0.262	0.2812	0.2906	0	0.3031	0	0	0.3	0.3562	0.362	1.66
0	0.2812	0.2906	0	0.3031	0	0.3218	0.3	0.3562	0.362	0.54
0.262	0.2812	0.2906	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.76
0.262	0.2812	0.2906	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.66
0.262	0.2812	0.2906	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.59
0	0.2812	0.2906	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.78
0.262	0.2812	0.2906	0.2937	0.3031	0.3187	0.3218	0.3	0.3562	0.362	0.37

Appendix E: the calculation of denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation

Table 1. Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 2

Cce.1	0.00	0.0022	0.0024	0.0022	0.0038	0.004	0.006	0.008
Cce.2	0.00	0.0002	0.0026	0.0050	0.0081	0.011	0.011	0.011
Cce.3	2.43E-06	4.95E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	4.43E-05	4.65E-05
Cce.4	0	0	0	0	0	0	0	0
Cce.5	0	0	0.0008	0.0016	0.0019	0.002	0.009	0.016
Cce.6	0.00	0.0019	0.0075	0.0132	0.0189	0.024	0.024	0.024
Cce.7	0.00	0.0045	0.0083	0.0120	0.0128	0.013	0.016	0.019
Cce.8	0.00	0.0002	0.0004	0.0005	0.0006	0.000	0.001	0.002
Cce.9	6.97E-05	0.000142	0.000194	0.000249	0.000443	0.00064	0.00128	0.00192
Cce.10	3.54E-08	6.87E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
(∑SEi×ROiP2×Wi)]	0.00	0.009	0.022	0.035	0.046	0.058	0.071	0.085
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.902
[D.U×(∑SEi×ROiP2×Wi)]	0.00	0.003	0.010	0.017	0.077	0.082	0.083	0.076

Table. 2 Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 3

Causes								
Cce.1	0.0011	0.0022	0.0024	0.0022	0.0038	0.0049	0.006	0.0087
Cce.2	0.0001	0.0001	0.0026	0.0050	0.0081	0.0112	0.011	0.0114
Cce.3	2.43E-06	4.95E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	4.43E-05	4.65E-05
Cce.4	0	0	0	0	0	0	0	0
Cce.5	0	0	0.0008	0.0016	0.0019	0.0022	0.009	0.0161
Cce.6	0	0	0	0	0	0	0	0
Cce.7	0.0022	0.0045	0.0083	0.0120	0.0128	0.0136	0.016	0.0192
Cce.8	0.0002	0.0002	0.0004	0.0005	0.0006	0.0009	0.001	0.0029
Cce.9	6.97E-05	0.000142	0.000194	0.000249	0.000443	0.00064	0.00128	0.00192
Cce.10	3.54E-08	6.87E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
∑SEi×ROiP3×Wi	0.0038	0.0073	0.0148	0.0218	0.0279	0.0336	0.047	0.0604
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025
∑[D.U×(∑SEi×ROiP3×Wi)]	0.000954	0.002584	0.006689	0.010916	0.046392	0.047201	0.05434	0.054591

Table 3, Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 4

Cce.1	0.0011	0.0022	0.0022	0.0022	0.0038	0.0049	0.006	0.0087
Cce.2	0.0001	0.0001	0.0050	0.0050	0.0081	0.0112	0.011	0.0114
Cce.3	2.43E-06	4.95E-06	1.23E-05	1.23E-05	2.73E-05	4.21E-05	4.43E-05	4.65E-05
Cce.4	0	0	0	0	0	0	0	0
Cce.5	0	0	0.0016	0.0016	0.0019	0.0022	0.009	0.0161
Cce.6	0	0	0	0	0	0	0	0
Cce.7	0.0022	0.0045	0.0120	0.0120	0.0128	0.0136	0.016	0.0192
Cce.8	0.0002	0.0002	0.0005	0.0005	0.0006	0.0009	0.001	0.0029
Cce.9	6.97E-05	0.000142	0.000249	0.000249	0.000443	0.00064	0.00128	0.00192
Cce.10	3.54E-08	6.87E-08	2.24E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
∑SEi×ROiP4×Wi	0.0038	0.0073	0.0218	0.0218	0.0279	0.0336	0.047	0.0604
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025
∑[D.U×(∑SEi×ROiP4×Wi)]	0.000954	0.002584	0.009824	0.010916	0.046392	0.047201	0.05434	0.054591

Table 4. Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 5

Cce.1	0.0011	0.0022	0.0024	0.0022	0.0038	0.0049	0.0068	0.0087
Cce.2	0.0001	0.0001	0.0026	0.0050	0.0081	0.0112	0.0113	0.0114
Cce.3	2.43E-06	4.95E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	4.43E-05	4.65E-05
Cce.4	0	0	4.59E-05	9.19E-05	0.000592	0.001092	0.001822	0.002552
Cce.5	0	0	0.0008	0.0016	0.0019	0.0022	0.0092	0.0161
Cce.6	0.0009	0.0019	0.0075	0.0132	0.0189	0.0245	0.0245	0.0245
Cce.7	0.0022	0.0045	0.0083	0.0120	0.0128	0.0136	0.0164	0.0192
Cce.8	0.0002	0.0002	0.0004	0.0005	0.0006	0.0009	0.0019	0.0029
Cce.9	6.97E-05	0.000142	0.000194	0.000249	0.000443	0.00064	0.00128	0.00192
Cce.10	3.54E-08	6.87E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
∑SEi×ROiP5×Wi	0.004801	0.00935	0.022508	0.035205	0.04745	0.059378	0.073465	0.087636
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025
∑[D.U×(∑SEi×ROiP5×Wi)]	0.0012	0.003273	0.010128	0.017602	0.078766	0.083189	0.084852	0.079092

Table 5. Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 6

Cce.1	0.0011	0.0022	0.0024	0.0022	0.0038	0.0049	0.0068	0.0087
Cce.2	0.0001	0.0001	0.0026	0.0050	0.0081	0.0112	0.0113	0.0114
Cce.3	2.43E-06	4.95E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	4.43E-05	4.65E-05
Cce.4	0	0	4.59E-05	9.19E-05	0.000592	0.001092	0.001822	0.002552
Cce.5	0	0	0.0008	0.0016	0.0019	0.0022	0.0092	0.0161
Cce.6	0.0009	0.0019	0.0075	0.0132	0.0189	0.0245	0.0245	0.0245
Cce.7	0.0022	0.0045	0.0083	0.0120	0.0128	0.0136	0.0164	0.0192
Cce.8	0.0002	0.0002	0.0004	0.0005	0.0006	0.0009	0.0019	0.0029
Cce.9	6.97E-05	0.000142	0.000194	0.000249	0.000443	0.00064	0.00128	0.00192
Cce.10	3.54E-08	6.87E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
∑SEi×ROiP6×Wi	0.004801	0.00935	0.022508	0.035205	0.04745	0.059378	0.073465	0.087636
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025
∑[D.U×(∑SEi×ROiP6×Wi)]	0.0012	0.003273	0.010128	0.017602	0.078766	0.083189	0.084852	0.079092

Table 6. Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 7

Cce.1	0	0	0	0	0	0	0	0
Cce.2	0.0001	0.0001	0.0026	0.0050	0.0081	0.0112	0.0690	0.0114
Cce.3	2.43E-06	4.95E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	0.006032	4.65E-05
Cce.4	0	0	4.59E-05	9.19E-05	0.000592	0.001092	0.044049	0.002552
Cce.5	0	0	0.0008	0.0016	0.0019	0.0022	0.0982	0.0161
Cce.6	0.0009	0.0019	0.0075	0.0132	0.0189	0.0245	0.1245	0.0245
Cce.7	0.0022	0.0045	0.0083	0.0120	0.0128	0.0136	0.0831	0.0192
Cce.8	0.0002	0.0002	0.0004	0.0005	0.0006	0.0009	0.0330	0.0029
Cce.9	6.97E-05	0.00014	0.0001	0.0002	0.0004	0.0006	0.0292	0.0019
Cce.10	3.54E-08	6.87E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	0.000909	1.18E-06
∑SEi×ROiP7×Wi	0.0036	0.0071	0.0200	0.0329	0.0435	0.0543	0.4882	0.0789
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025
∑[D.U×(∑SEi×ROiP7×Wi)]	0.000924	0.002499	0.009012	0.016498	0.072332	0.076211	0.563964	0.071221

Table 7. Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 8

Cce.1	0.00	0.0022	0.0024	0.0022	0.0038	0.0049	0.0068	0.0087
Cce.2	0.00	0.0001	0.0026	0.0050	0.0081	0.0112	0.0113	0.0114
Cce.3	2.43 E-06	4.95E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	4.43E-05	4.65E-05
Cce.4	0	0	4.59E-05	9.19E-05	0.000592	0.001092	0.001822	0.002552
Cce.5	0	0	0.0008	0.0016	0.0019	0.0022	0.0092	0.0161
Cce.6	0.00	0.0019	0.0075	0.0132	0.0189	0.0245	0.0245	0.0245
Cce.7	0.00	0.0045	0.0083	0.0120	0.0128	0.0136	0.0164	0.0192
Cce.8	0.00	0.0002	0.0004	0.0005	0.0006	0.0009	0.0019	0.0029
Cce.9	6.97 E-05	0.000142	0.000194	0.000249	0.000443	0.00064	0.00128	0.00192
Cce.10	3.54 E-08	6.87E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
∑SEi×ROiP8×Wi	0.0048	0.0093	0.0225	0.0352	0.0474	0.0593	0.0734	0.0876
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025
∑[D.U×(∑SEi×ROiP8×Wi)]	0.0012	0.003273	0.010128	0.017602	0.078766	0.083189	0.084852	0.079092

Table 8. Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 9

Cce.1	0.001105	0.002209	0.002481	0.002209	0.003876	0.004981	0.006841	0.008721
Cce.2	0.000102	0.000178	0.002615	0.005078	0.008151	0.011249	0.011325	0.011426
Cce.3	2.43E-06	4.95E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	4.43E-05	4.65E-05
Cce.4	0	0	4.59E-05	9.19E-05	0.000592	0.001092	0.001822	0.002552
Cce.5	0	0	0.0008	0.0016	0.0019	0.0022	0.0092	0.0161
Cce.6	0	0	0	0	0	0	0	0
Cce.7	0.0022	0.0045	0.0083	0.0120	0.0128	0.0136	0.0164	0.0192
Cce.8	0.0002	0.0002	0.0004	0.0005	0.0006	0.0009	0.0019	0.0029
Cce.9	6.97E-05	0.000142	0.000194	0.000249	0.000443	0.00064	0.00128	0.00192
Cce.10	3.54E-08	6.87E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
∑SEi×ROiP9×Wi	0.0038	0.0073	0.0149	0.0219	0.0285	0.0347	0.0488	0.0630
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025
∑[D.U×(∑SEi×ROi P9×Wi)]	0.000954	0.002584	0.00671	0.010962	0.047375	0.048732	0.056445	0.056895

Table 9. Denominators and nominators for statistical fuzzy modeling percentage of causes of cost escalation for project 10

Cce.1	0.00	0.0022	0.0024	0.0022	0.0038	0.0049	0.0068	0.0087
Cce.2	0.00	0.0001	0.0026	0.0050	0.0081	0.0112	0.0113	0.0114
Cce.3	2.43 E-06	4.95E-06	8.68E-06	1.23E-05	2.73E-05	4.21E-05	4.43E-05	4.65E-05
Cce.4	0	0	4.59E-05	9.19E-05	0.000592	0.001092	0.001822	0.002552
Cce.5	0	0	0.0008	0.0016	0.0019	0.0022	0.0092	0.0161
Cce.6	0.00	0.0019	0.0075	0.0132	0.0189	0.0245	0.0245	0.0245
Cce.7	0.00	0.0045	0.0083	0.0120	0.0128	0.0136	0.0164	0.0192
Cce.8	0.00	0.0002	0.0004	0.0005	0.0006	0.0009	0.0019	0.0029
Cce.9	6.97 E-05	0.000142	0.000194	0.000249	0.000443	0.00064	0.00128	0.00192
Cce.10	3.54 E-08	6.87E-08	1.47E-07	2.24E-07	6.58E-07	1.09E-06	1.14E-06	1.18E-06
∑SEi×ROiP10×Wi	0.0048	0.0093	0.0225	0.0352	0.0474	0.0593	0.0734	0.0876
Discrete universe	0.25	0.35	0.45	0.5	1.66	1.401	1.155	0.9025
∑[D.U×(∑SEi×ROiP10×Wi)]	0.0012	0.003273	0.010128	0.017602	0.078766	0.083189	0.084852	0.079092