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Socio-Political and Macro-Economic Impact of Tender Price Inflation in Zambian Public Construction Projects

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Abstract

A well-managed tender price allows governments to improve sustainable construction. Currently, there is no tender price management model to regulate tender price inflation in public projects in Zambia. The paper aims to develop a model that proposes a practical solution to critical challenges related to tender price inflation in public projects in the Zambia. The study utilized mixed methods, in which purposive snowball sampling was used to identify 14 participants for interviews to investigate socio-political factors, and a questionnaire survey administered to 170 project management practitioners to investigate economic factors that influence tender price inflation in the Zambian construction industry. Equations were derived from ordinary least squares (OLS) method to determine an optimum domain-specific tender price, while the qualitative data provide the basis for socio-political strategies. Findings show that the model has unlimited prediction capabilities while accounting for various correlations between volatilities. Further, combining the quantitative and qualitative platforms of the model facilitates a low variable tender-price output that is critical to the predictability and certainty in determining the ability of the project to meet interest and fund redemption. Key practical benefits of providing a construction model with low inflation in tender-price include of improved cost predictability. The conclusion of the study is that a model that reduces inflation in tender prices enables more accurate budgeting, helping stakeholders plan projects with a higher degree of certainty. This reduces the risk of cost overruns and allows for better resource allocation. The value of this study lies in its originality, as it presents the first comprehensive tender price management model specifically tailored to public construction projects in Zambia, offering an innovative solution to the persistent challenge of tender price inflation, and contributing significantly to the improvement of sustainable infrastructure development.

Keywords: construction, infrastructure development, management model, public sector, tender price.

1. Introduction

Contractors determine the tender price by maximizing expected profit while factoring in the probability of winning the bid, underlying conditions of bid items, client characteristics, and competition level. However, Wang et al. (2012) affirm that making accurate pricing in a bid is enormously expensive and time-consuming. Historical data must be readily available to predict the bid price. Necessary documentation and processes for adjusting unit costs must be available also. Underutilization of historical project cost data exacerbates cost control challenges during tendering (Zhang et al., 2015). Also, simplified and streamlined pricing models often involve the imposition of arbitrary and subjective constants and price limits (Cattell et al., 2007). Using such arbitrary values fails to provide a scientific basis by which to construct an optimum tender price. Kissi et al. (2019) hypothesized the existence of a relationship between the different pricing strategies and the factors that influence the pricing of a tender. Tender price management is the most crucial consideration for bid success. However, due to complex interrelationships, it is easier to express project success in terms of cost and budget variance (Yismalet & Patel, 2018).

Currently, there is no tender price management model to regulate tender price inflation in Zambia. This has far-reaching implications beyond economic inefficiencies. Tender price inflation has

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led to stalled or incomplete public projects, compromising the development of critical social infrastructure such as schools, hospitals, and transportation systems. The ripple effects are particularly severe in such an emerging economy like Zambia, where public construction projects are often essential for addressing social inequities and promoting economic development. When project costs are unpredictable and inflated, government budgets are strained, leading to resource allocation challenges and delays in delivering essential services to the population.

This study aims to develop a tender price management model specifically tailored to public construction projects in Zambia. The importance of this model is beyond financial predictability, it is crucial for ensuring the sustainability and timely completion of public infrastructure projects that are key to social development. While tender price management may havereceived considerable attention in normative literature, existing models are either generic or not specific to the unique socio-political and macro-economic conditions of Zambia. This geographical and contextual focus is essential as it aims to fill a gap by creating a model that addresses local challenges.

Tender price inflation in Zambia is not merely a financial issue but one that significantly impacts social outcomes. For instance, inflation-driven project delays or cancellations disrupt the provision of essential infrastructure, affecting public health, education, and transportation. This study acknowledges that the absence of a standardized tender price management model has contributed to inefficiencies and uncertainty in public sector projects, with substantial social implications. Therefore, the study's objective is to provide predictability and control over these price fluctuations through a context-specific model that considers both quantitative economic factors and qualitative socio-political influences.

The contribution of this study lies in its contextual adaptation, providing a model that considers local economic volatility, exchange rate fluctuations, and the influence of political factors on public construction projects. This holistic approach is relatively novel in the discourse of tender price management and represents an advancement in managing prices in unpredictable economies.

By focusing on macro-economic and socio-political factors, this study bridges the gap between existing tender price management models.

2. Literature Review

Tender price inflation poses significant challenges to the successful implementation of public construction projects, particularly in developing economies like Zambia. While the phenomenon of tender price volatility has been widely explored in global construction literature, there is limited research that addresses the specific socio-political and macro-economic factors contributing to this in Zambia. Developing a robust model to mitigate tender price inflation requires an understanding of both external factors, such as inflation and currency fluctuations, as well as socio-political influences, including governance, policy shifts and institutional stability. This literature review examines existing models of tender price management by focusing on their applicability to public sector infrastructure projects. Further, the review explores critical socio-political and macro-economic factors that influence tender price inflation in Zambia. This review highlights the gaps in current models and provides a foundation for developing a tailored solution for Zambia's unique construction sector challenges.

2.1. Understanding Tender-Price Inflation

Tender price inflation refers to the sustained increase in the cost estimates provided by contractors for identical scopes of work in a construction project, primarily driven by persistent rises in input costs such as labor, materials, and equipment. Unlike general price inflation, which reflects broader economic trends, tender price inflation is specific to the construction sector and is influenced by both internal project dynamics and external market conditions, including supply chain disruptions, regulatory changes, and market demand. It leads to consistently higher tender bids over time, rather than mere price fluctuations among contractors. While bid variation may occur due to competitive strategies or project-specific risks, inflation inherently results in upward pressure on prices rather than reductions.

Several key factors contribute to tender price inflation. These include the cost of labor and equipment, which can increase due to shortages or rising wages, and material supply constraints, where local availability or reliance on imported materials may drive up prices. External market conditions, such as global economic shifts, currency fluctuations, and inflation rates, also play a significant role (Vu, et al., 2020). Additionally, site-specific challenges like safety requirements, access limitations, or geographical constraints can increase the cost of execution, reflecting in higher tender prices. Effectively managing tender price inflation requires a thorough understanding of these influences and the ability to anticipate fluctuations. Strategic pricing of risk factors—such as unpredictable market conditions or site constraints—enables more accurate budgeting and risk management, ensuring project costs remain firm while minimizing the impact of tender price volatility (Cho, et al., 2024).

2.2. *Benefits of Low Variability in Tender-Price Output*

A principle of management in any organization is that future conditions are uncertain, and such uncertainty poses a significant risk to the success of the project. Thus, construction stakeholders try to make an effort to reduce the impacts of future uncertainty during project processes. Variability in the tender price output, following a tender period, is treated in this research as a critical factor seeking attention in project controls to help in the development of construction project success. Therefore, understanding one of the outputs of a tendering process, i.e. the variability in tender price output, is a crucial factor for clients involved in construction projects. The main concern for a project client at the tender price level output is cost certainty (Cunningham, 2015). This aids in budgeting for a particular project at the construction phase, in a bid to either plan for an additional source of payment, and to gauge sources of project finance to avoid project abandonment resultin from shortage of fund. Fund shortage occurs because actual project costs exceeds tender price without variations to project scope. Results have also shown that clients can anticipate having a proactive duty-setting mechanism ahead of time to offset such shortage of funds.

2.2.1 *Cost Certainty*

Project budgeting is a prominent step in the acquisition process of any new project, detailing if any, to what extent, and in which categories the expenditure of a project impacts upon a particular owner's portfolio (Aje, et al., 2016). It is the cost consultant's responsibility to design a cost plan that can be used to validate the commercial viability of a particular development proposal. Predictability and certainty in tender-price outputs allow investors to determine the ability of the business or project to meet stakeholders' interests and maintain a dividend payout that keeps the firm or equity investment in good standing with the investors. Investors require reliable data on costs to objectively compare investment opportunities. Without the aid of providers of construction models with low variability at the time of contract award, operating an efficient construction contract appears most difficult and remote to achieve.

2.2.2 *Enhanced Risk Management*

Providing a construction model with low variability in its tender price outputs offers benefits to those who participate in such tenders. Hence, this creates the opportunity to provide the skills, materials and services in the construction projects that are eventually commenced. Risk management practices assume that an accurate risk assessment can be made, but low variability in tender prices suggests that pricing dynamics are predictable. Anticipation of what can happen in the immediate future is the ability to perceive change before it occurs. Pricing dynamics predictability should be used to create project-specific risk communications from in-depth analysis to superficial overviews that match risk-taking and risk-deterring behaviors of various stakeholders. It can also be used as input for project-specific risk monitoring plans. Enhanced risk management should reduce unplanned expenses, other impacts, and their accumulation throughout project lifecycle (Keshk, et al., 2018). The more aggressive risk bearers require, the more detailed risk communications are. It is also important because active risk management is shown by low variability in tender prices. The most efficient use of these initial resources is for the tenderer to use tender documentation that can be completed and submitted for as many tenders as possible (Akintoye & Fitzgerald, 2000).

2.3. *Factors Influencing Tender Price Inflation*

Many diverse internal, sometimes risk-related, and external elements influence tender price inflation. Market demand and competition directly lead to price inconstancy over time. In addition, it is necessary to consider two rational contractor behavioral theories. One contractor is positioned upmarket and, compared to another, is thus the price leader, and it thereby tends to reflect or set market-only tender prices theoretically. The reactions of the other contractors to input price variations over time are determined by their lifecycle costs and experience profiles. Short-term cost variations are averaged out in the contractors' tender pricing by zeroing local construction project operation losses against their wider portfolio and operational profits. Unstable crude oil prices are also weighted into local transportation costs only and thereafter into local labor, building material, and equipment construction costs, which are then incurred by contractors.

2.3.1 *Sociopolitical Factors*

Socio-political factors are predetermined by traditional and political stimulus in which the government and society influence a sector's ability to achieve broader economic goals. Zhang et al. (2006) explain how existing theoretical principles of project risk management are inadequate about realistic considerations. Thus, risks remain unallocated and are unreasonably priced at the project onset. For example, Naji & Ali (2017) found that one of the main risks for consideration is the financial capacity of the client, whether they are able to pay the contractor timely. Failure to do so often leads to project delays and cost estimation errors. Further, the failure of a construction firm to fully consider or estimate the impact of risk events on construction operations could cause construction prices to escalate. Laryea & Hughes (2008) found no evidence suggesting that construction project pricing was systematic. Therefore, they doubted the justification of pricing models for contractors as their final price depends on a varying range of complex microeconomic indicators and risk factors. Their argument hinges on efficient pricing for risk while encountering and estimating various factors. Gudienė et al. (2013) and Tembo et al. (2020) identified and classified these factors into seven major groups, namely: external, institutional, project-related, project team management-related, project manager-related, client-related and contractor-associated factors. Further, Gudienė et al. (2013) developed a model that grouped project success factors to investigate how these factors influenced the success of a construction project. However, they did not explore underlying relationships among the elements.

Nguyen & Q. Nguyen (2020) argue that construction price level is very informative on changes in the construction industry as it arises from a combination of results regarding labor, materials, and equipment cost variables. They identified five critical factors that affect construction tender prices. These include consumer price index, gross domestic product, interest rates, foreign exchange rate, and total imports and exports. On the other hand, Vansteenkiste et al. (2019) argue that labor wages and price inflation show a dynamic interaction primarily dependent on the state of the economy. This means, in practice, labor costs are passed on to price inflation, and are exercebated with demand shocks. Cruywagen (2014) argues that several factors, including data availability, influence the establishment and the composition of the relevant tender price index. Other factors by Cruywagen include the base year or period, choices of weights and construction method. Once established, the index works as a deflator for construction prices. In summary, in a free market, the bidder presents an item price uniquely dependent on the construction technique (Cattell et al., 2010).

2.3.2 *Economic Factors*

Table 1 summarizes the literature review on macroeconomic variables relating to construction tender prices and shows that exchange rate, inflation, interest rates, labor force, and unemployment rate are crucial to the price level in construction. In addition, the paper adds other local macroeconomic factors that experts recommend when implementing construction projects.

Zambia's Macroeconomic Context

Inflation rate

Inflation rate in Zambia averaged 9.68% between 2005 and 2019, reaching an all-time high of 22.90% in February 2016 and a record low of 6% in December 2011 (Trading-Economics, 2022). The construction tender price is subject to the effects of inflation (Bai, 2014). Monfared & Akin (2017) agree that "an increase in foreign exchange rates also raises inflation", increasing general prices in the broader economy, including construction tender prices. To promote economic growth, the government should keep inflation low (Kasidi & Mwakanemela, 2013).

Interest rate

Interest Rate in Zambia averaged 10.25% between 2012 and 2019, reaching an all-time high of 15.50% in November 2015 and a record low of 9% in May 2012 (Trading-Economics, 2022). Instead of paying attention to the relationship between interest rate and price level, Thornton (2012) argues that money is even more essential for economic activity in the construction sector and determining the price level, not interest rates.

Public debt

Government Debt in Zambia increased from USD8.915 billion in 2017 to USD10.05 billion in 2018. The debt averaged USD4.61 billion between 2002 and 2018, reaching an all-time high of USD10.05 billion in 2018 and a record low of USD1.11 billion in 2007 (Trading-Economics, 2022). Zambia's debt to Gross Domestic Product was 59 percent in 2018. Further, Zambia's external debt rose from USD8.3 billion in 2017 to USD9.15 billion in 2018, averaging USD4.5 billion between 2008 and 2018, and an all-time high of USD 9.21 billion in 2016 and a record low of USD0.91 billion in 2008 (Trading-Economics, 2022). Public debt significantly affects inflation and *vice versa.* This is because a high government debt depresses income and stimulates direct price level (Maitra, 2019).

2.4. *Techniques for Achieving Low Variability*

In construction projects, achieving a consistent tender price output with minimal variability is essential for reducing commercial disputes and supporting informed decision-making. Here are three main techniques from literature that help achieve low variability in tender prices:

- **Detailed market analysis**: Conducting thorough market research allows for evidence-based decisions, which help in setting realistic and competitive prices (Pascucci, et al., 2023). By understanding current market trends, labor costs, material availability and demand, decision-makers can anticipate fluctuations and make adjustments that promote price stability.

- **Utilizing historical information from within the organization:** Leveraging historical data from past projects provides insights into cost structures, efficiency levels and pricing strategies that had worked in the past (Yaiprasert & Hidayanto, 2024). This technique relies on an organization's own experience and allows for more accurate forecasting by recognizing patterns and

Table 1: Macroeconomic variables affecting construction price

Variables	(Arditi et al., 2000)	(Ngowi et al., 2005)	(Enshassi et al., 2009)	(Oladipo & Oni, 2012)	(Choi, et al., 2013)	(Jiang & Liu, 2015)	(Chilongo & Mbetwa, 2017)	(Cheelo & Liebenthal, 2018)	(Asamoah et al., 2019)	(Kirchberger, 2020)	(Musarat et al., 2021)	(Makoye et al., 2022)
Exchange rate				x					x			
Inflation			x	x					x		x	x
Interest rate	x			x		x	x	x	x			x
Imports				x								
Money supply				x								
Export				x		x						
Gross Domestic Product				x					x			
External debt				x								
Money supply				x								
Labor force			x		x	x	x	x		x		x
External reserve				x								
Balance of payment				x								
Industry weakness	x											
Poor growth prospect	x											
Consumer price index									x			
Black market									x			
Cost of raw materials										x		
Unemployment rate				x	x	x				x		
Construction price level					x	x						
Globalization		x										

Source: Authors

identifying cost drivers that influence variability.

- **Utilizing similar projects from the past:** Reviewing data and outcomes from similar projects conducted by other organizations can offer valuable insights into potential pricing models and benchmarks (Fleckenstein, et al., 2023). This approach broadens the knowledge base by incorporating external perspectives, helping to anticipate potential risks and cost variations that may not be immediately apparent from internal data alone.

Each of these techniques provides a strategic foundation for developing consistent tender prices. Combining these approaches can offer a comprehensive understanding of market conditions and historical trends, helping project stakeholders to plan and adjust tender prices effectively. Early identification of pricing variables through these methods, along with continuous refinement during stakeholder workshops, allows for more accurate and stable pricing that aligns with project requirements.

2.4.1 Models Regarding Construction Tender Price

Table 2 summarises strengths and weaknesses observed in relevant previous studies that developed models regarding construction tender prices. Closely associated models tend to focus on predicting movements in the tender price index, simulating the bidder's profit and determination of profit ratio and forecasting the tender-price index (Wong & Ng, 2010: 1255; Yiu & Tam, 2006: 475; Akintoye, 1991; and Jaśkowski & Czarnigowska, 2019: 159). Other studies with a similar focus include those of Kissi et al. (2018: 70; 2017: 252) and Olatunji (2008: 60). Wong & Ng (2010), Yiu & Tam (2006), Akintoye (1991) and Jaśkowski & Czarnigowska (2019) have focused on similar issues, offering frameworks that calculate profit ratios or forecast price indices. However, these models often fail to provide a comprehensive solution, as they emphasize either the economic aspect of tender price prediction or focus narrowly on profit optimization, without integrating broader market or project-specific variables. Similarly, Kissi et al. (2018, 2017) and Olatunji (2008) have explored tender price prediction models. Olatunji (2008: 60) explains how ordinary least squares (OLS) is used to predict tender prices in Nigeria. However, this model only focuses on the analytical computation and lacks adaptability to varying market conditions. The research highlights the challenges in managing and developing tender price models, emphasizing that existing models primarily concentrate on predicting tender price index movements, simulating bidder profit margins, and forecasting tender prices. In contrast, this current research's focus is identical to Ho (2013: 1248) which developed a Grey model for forecasting price indices and the likely tender price of a given project. The model is also statistically unstable for small sample sizes, involves solving complex equations. However, Ho's model is time-consuming to implement. It is also rigid and does not incorporate new information. The key issue across these models is their rigidity, complexity, and the absence of mechanisms to incorporate new market data dynamically. Therefore, this current research seeks to address these limitations by developing a flexible and comprehensive model, integrating both economic factors and socio-political influences to better predict and manage tender prices in the Zambian public construction sector.

2.4.2 How Reviewed Models Shape the Proposed Framework

Grey Model (GM) was developed by Ho (2013) for forecasting tender price indices. It is limited by adaptability and struggles with small sample sizes. This proposed framework will incorporate mechanisms for flexible data inputs and a broader sample range. Additionally, Olatunji's (2008) OLS-based model. Whilst the model analytically useful, it fails to incorporate socio-political dynamics. The new framework corrects this by integrating both economic and socio-political factors to provide a more comprehensive model suited for Zambia's public sector projects. Each of these models, although successful in specific contexts, contributes specific lessons on how to better manage tender price variability in Zambia. By clearly identifying these potential contributions, further discussions in this section will flow into and shape the conceptual framework, ensuring that the framework builds on the strengths and addresses the weaknesses of previous models.

The literature review has highlighted critical gaps and insights from existing studies, which collectively informs the rationale and development of a tender price management model specifically tailored for Zambia's public construction projects. Below is a synthesis of how the identified gaps shape the proposed model.

- **Integration of Socio-Political and Macro-Economic Factors:** Existing models, such as those by Olatunji (2008) and Ho (2013), focus heavily on economic predictions, neglecting socio-political influences that play a critical role in tender price variability, especially in volatile economies like Zambia's. These models fail to account for local governance issues, political stability, and institutional capacities, which are central to Zambia's construction sector's challenges. The proposed model incorporates these socio-political factors by integrating governance structures, political interference, and regulatory dynamics alongside macro-economic variables such as inflation, exchange rates, and interest rates. This multidimensional approach provides a comprehensive framework to predict and manage tender price inflation effectively.

  Adaptability to Dynamic Market Conditions: Ho's (2013) Grey Model (GM) and Kissi et al.'s (2018) ARIMAX model are limited in their adaptability to fluctuating market conditions and small sample sizes. These models often lack the flexibility to incorporate new market data dynamically. The proposed model addresses this limitation by leveraging mechanisms for continuous data inputs and real-time adjustments. The inclusion of Ordinary Least Squares (OLS) regression ensures that the model remains responsive to economic changes and allows for accurate predictions under varying conditions.

- **Bridging Analytical and Contextual Gaps:** Zhang et al. (2015) and Wang et al. (2007) emphasized the importance of robust analytical frameworks but overlooked the contextual realities of emerging markets. For instance, Zambia's unique economic volatility, high levels of government debt, and external market dependencies are not reflected in existing models. By combining quantitative methods with qualitative assessments, the

Table 2: Summary of previous studies on models regarding construction tender price

Continent	Country	Author	Model	Strength	Weakness
Asia	China	Zhang, et al. (2015: 606-614)	System for construction tender price evaluation based on big data	Use big data to give a reasonable project cost range Establish price controls	How to revise and refine algorithms to improve the degree of automation of bid data and result accuracy
	Malaysia	Hassim, et al. (2018: 443-457)	Estimating model for pre-tender estimation process using fuzzy logic combined with neural network method	Assist with the pre-tender estimation, enabling the client to make early funding arrangements. Assist contractors in coming up with more accurate tender-price estimations.	The model estimated cost is subject to the accuracy of the rating of factors.
	Taiwan	Wang, et al., (2007: 223–235)	Simulation-based cost model	Assesses cost uncertainties Improves bid price decision quality	The model does not account for the effects of tendering method and project type.
	Hong Kong	Tan & Goh (2017: 173-198)	Grey model (GM) for forecasting price indices	Forecast the likely tender price of a given project	The model performs poorly in the face of dramatic fluctuation in the dependent variables, as is the case with developing countries Statistically unstable for small sample sizes It involves solving complex equations Time-consuming The model does not incorporate new information
		Wong & Ng (2010: 1255–1268)	Vector error correction model	Provides medium-term forecasts in tender price movements	Limited to predictions of tender price index patterns
		Yiu & Tam (2006: 475-484)	Real options model	Describes bidders' underpricing phenomenon	The model does not consider correlations between the option value and macroeconomic volatilities.
Europe	United Kingdom	Akintoye & Skitmore (1990: 31-47)	Construction price causal model using simultaneous equations focusing on construction demand and supply models	Predict movements in the tender-price index.	The model does not incorporate changes in the composition of the construction market aggregate tender-price
	Poland	Jaśkowski & Czarnigowska (2019: 159–166)	Modified Friedman's Model with correlations	Simulates bidder's maximum profit margin and determination of profit ratio	Assumes positive correlations between competing bid prices
	Macedonia	Petruseva, et al. (2016: 143-151)	Support Vector Machine (DTREG Software Package)	Predicts bid price with high accuracy	The algorithm underperforms for large data sets and requires higher training time.
Africa	Ghana	Kissi, et al. (2018: 70-82)	Autoregressive integrated moving average with exogenous (ARIMAX) model	Forecasting tender-price index	Difficulties in predicting accumulated time series
		Kissi, et al. (2017: 252-268)	Structural model for tender price determination	Provides causal relations regarding the degree of influence of factors that affect tender pricing	The model does not forecast accumulated time series and fails to account for the effects of extant price levels.
	Nigeria	Olatunji (2008: 60-79)	Model for predicting project final construction cost and period	Investigate the relationship between tender price and final construction costs	The model fails to account for sociopolitical issues relating to non-economic dimensions of the industry

Source: Authors

proposed model bridges this gap. The inclusion of qualitative data, such as stakeholder interviews and thematic analysis of governance factors, ensures that the model reflects Zambia's unique socio-economic landscape.

Improving Cost Certainty and Risk Management: Laryea and Hughes (2008) underscored the importance of cost certainty and risk management in construction tendering. However, their approach was primarily theoretical, with limited application to developing economies facing external shocks. The proposed model extends this work by providing actionable strategies for mitigating risk factors at the inception of projects. The integration of predictive analytics and qualitative insights enables project stakeholders to anticipate cost fluctuations, enhancing cost certainty and reducing the risk of tender price inflation.

- **Local Relevance and Tailored Interventions:** Existing models, such as those developed in Asia and Europe (e.g., Wong & Ng, 2010; Akintoye & Skitmore, 1990), focus on stable markets where tender price dynamics are influenced primarily by supply-demand principles. These models are less applicable to Zambia, where political instability, corruption, and market unpredictability significantly influence tender prices. The proposed model is designed specifically for Zambia, incorporating localized factors such as currency depreciation, delayed government payments, and reliance on imported materials. This contextual adaptation ensures that the model addresses the root causes of tender price inflation in Zambia.

Alejandro and Zhao (2024) investigate the critical role that institutional frameworks play in stabilizing construction price volatility in emerging markets. Their study highlights how robust governance structures, clear regulatory guidelines, and anti-corruption policies can significantly reduce uncertainties in tender pricing. The authors draw on case studies from three emerging economies to show that stronger institutional frameworks foster transparency, improve contractor confidence, and encourage competitive pricing. Their research also emphasizes the importance of aligning institutional policies with macro-economic realities, such as inflation and currency fluctuations, to enhance price stability. This study is particularly relevant for Zambia, where weak institutional oversight has been a major contributor to tender price inflation, suggesting that strengthening governance mechanisms could help mitigate these challenges.

In their research, Musarat, Alaloul, and Liew (2024) delve into the interplay between inflation rates, labor market dynamics, and construction tender prices in Sub-Saharan Africa. They demonstrate that inflationary pressures, combined with high labor turnover and skill shortages, significantly inflate project costs, thereby impacting tender prices. Using data from multiple Sub-Saharan countries, their study identifies strategies for mitigating these effects, such as indexing tender prices to inflation rates and implementing workforce stabilization programs. Their findings provide actionable insights for Zambia, where tender price inflation is exacerbated by rapid cost escalations in labor and materials. This study underscores the need for policies that address economic volatility and workforce issues to ensure more predictable and competitive tender pricing.

Grand-Guillaume-Perrenoud, Geese, and Uhlmann (2023) propose a mixed-methods approach to tender price modeling that combines quantitative economic data with qualitative assessments of socio-political influences. Their research argues that relying solely on quantitative models often overlooks contextual factors, such as governance challenges and contractor behavior, which are pivotal in tender price determination. By integrating stakeholder interviews, policy reviews, and economic simulations, the study provides a holistic framework for analyzing tender price variability. The proposed approach is particularly useful for Zambia, where socio-political factors such as policy instability and delayed government payments often interact with economic variables to influence tender prices. This study supports the need for models that incorporate both economic and qualitative dimensions to address the complexities of public sector tendering.

Fleckenstein, Obaidi, and Tryfona (2023) focus on the application of big data analytics to predict tender price indices in developing economies. Their research highlights how large datasets, including historical project costs, macro-economic indicat (Alejandro & Zhao, 2024) (Musarat, et al., 2024) (Grand-Guillaume-Perrenoud, et al., 2023) (Fleckenstein, et al., 2023)ors, and contractor performance records, can improve tender price forecasting accuracy. They showcase case studies where machine learning algorithms were used to analyze complex, multi-dimensional data, leading to more precise and reliable tender price estimates. This study has strong implications for Zambia, where the underutilization of historical data is a known issue in tender price management. By integrating big data analytics into existing frameworks, Zambia's construction industry could enhance price predictability and mitigate the risks of cost overruns and inflated bids.

2.5. Conceptual Framework

The basis of the structure of the proposed model in this study is the conceptual framework presented in Figure 1. The groups include macroeconomic (quantitative) and socio-political (qualitative) factors. The conceptual framework of this study is grounded in both economic and socio-political factors, recognizing that tender price inflation in public construction projects is shaped by a dynamic interplay between these two domains. Economic factors such as inflation rates, currency fluctuations, material costs, and labor pricing directly influence the cost structures of construction projects, creating variability in tender submissions (Musarat, Alaloul, & Liew, 2024). These factors determine the financial feasibility of projects and impact the accuracy of budget forecasts. In addition, socio-political

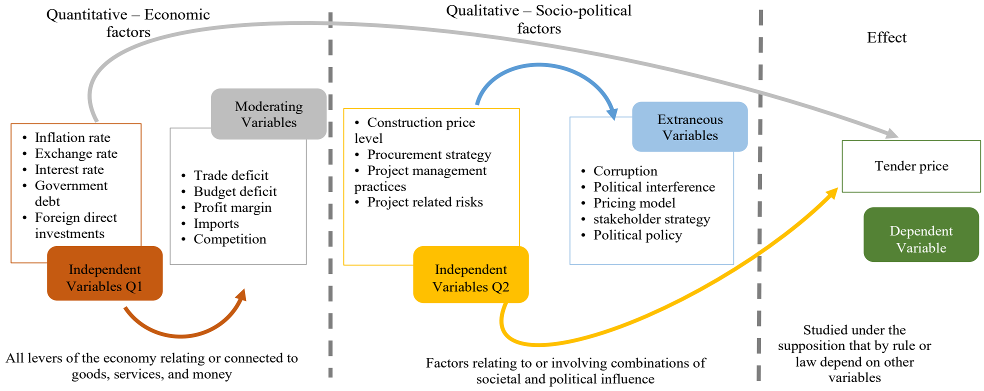

Figure 1: Conceptual framework.
Source: Authors

factors—including government policies, regulatory environments, political stability, and institutional governance—affect the decision-making processes within public sector projects (Aiyede, 2023). Changes in political leadership, policy shifts, and regulatory uncertainty can lead to fluctuations in tender prices by altering the operational landscape of the construction industry. By integrating these two sets of influences, the conceptual framework offers a comprehensive understanding of the forces driving tender price inflation, providing a robust basis for developing strategies to mitigate price volatility and improve project cost management.

2.5.1 Theory Underpinning the Conceptual Framework

The conceptual framework is built upon the systems theory and institutional economics theory. Systems theory views the construction tender price management process as a dynamic system influenced by multiple interconnected factors, including economic variables, socio-political influences, and institutional constraints (Boateng, et al., 2017). Institutional economics further supports the framework by highlighting the role of governance structures, regulations, and market forces in shaping economic activities, including tender pricing in public projects (Arwani & Unggul, 2024). This combination helps explain the complex interrelationships between socio-political and economic factors in influencing tender price inflation.

2.5.2 Theory Shaping the Conceptualization and Hypothesized Relationships

The conceptualization of the framework is shaped by economic theory (particularly market efficiency and supply-demand principles) and political economy theory. Economic theory informs the quantitative relationships between factors such as inflation, material costs, and labor pricing, which directly affect tender price variability. Political economy theory explains how political stability, governance, and regulatory environments impact public sector procurement and construction pricing. The hypothesized relationships are derived from the interaction between these economic drivers and socio-political conditions, proposing that tender price inflation is a result of both macroeconomic fluctuations and socio-political dynamics.

2.5.3 Rationale for Qualitative and Quantitative Approaches

Socio-political factors were assessed qualitatively because they involve complex, context-specific elements such as governance, political stability, and institutional frameworks that are better understood through in-depth interviews, case studies, and thematic analysis (Alejandro & Zhao, 2024). These factors are less easily quantified, and qualitative methods allow for a nuanced understanding of how these influences affect tender prices.

Economic factors, on the other hand, were assessed quantitatively using data-driven methods (e.g., OLS regression analysis) because they involve measurable variables like inflation rates, material costs, and labor pricing (Stanić & Račić, 2019). These variables can be analyzed statistically to determine their direct impact on tender price fluctuations, allowing for predictive modelling.

2.5.4 Impact of Different Approaches on the Framework's Validity

The use of mixed methods—qualitative for socio-political factors and quantitative for economic factors—enhances the validity of the proposed framework by ensuring that the model is both comprehensive and contextually grounded. By combining qualitative insights with quantitative rigor, the framework can better capture the complexity of real-world tender price dynamics. Qualitative assessments provide depth and context, ensuring that the model considers factors beyond numerical data, while the quantitative approach ensures that the relationships between economic variables are statistically validated. This mixed-methods approach improves the overall construct validity, ensuring that the framework accurately reflects the multifaceted nature of tender price management (Grand-Guillaume-Perrenoud, et al., 2023).

3. Methodology

3.1. Research Design

The study is phenomenological-driven within a qualitative and quantitative paradigm (Johnson & Onwuegbuzie, 2004; Yu & Khazanchi, 2017). The study utilized a triangulation design of mixed methods to obtain different yet supplementary data on construction-tender price inflation. The study conducted structured interviews with officials (contractors, consultants, and government officials) from the Zambian construction industry. In this study, the questionnaire set six constructs, including government, contractor, industry, procurement, legal, and related strategies extracted from interviews. Ordinary Least Square regression models were used to develop the analytical aspect of the model.

3.2. Population, Sample, and Response Rate

For quantitative samples, the study utilized a proportionate stratification approach for determining the sample size in each category due to the distinctive categorical nature of the population under consideration (Bless et al., 2020; Sibanyama et al., 2012). The sample size determination considered a 5% margin of error and a 95% confidence level and adopted Cochran's method or formula for calculating the categorical quantitative data sample size (Cochran, 1977; Bartlett et al., 2001).

$$n_s = \frac{pqt^2}{d^2} = \frac{0.5x0.5x1.65^2}{0.05^2} = 272$$

Where pq is the estimated variance = 0.25
Where t is the value of selected alpha level =1.65 for a level of 0.025 in each tail
Where d is the acceptable margin of error = 5%

Therefore, for a population of 454, the required sample size is 272. However, since the sample size is 26% (exceeds 5%; [454*0.05=22.7]) of the population, the study utilized Cochran's (1977) formula to recalculate the final sample size as follows:

$$n_f = \frac{n_s}{\left(1 + \frac{n_s}{population}\right)} = \frac{272}{\left(1 + \frac{272}{454}\right)} = 170$$

The study randomly selected practicing participants to ensure relevancy and provision of the necessary information on tender price information. Out of 170, the study accepted 147 usable questionnaires, resulting in a response rate of 86.5%.

For the qualitative sample, as shown in Table 4, field research shows that a representative sample of twelve interview participants is adequate to reach theoretical data saturation (Braun & Clarke, 2016; Boddy, 2016; Guest et al., 2006). The study employed purposive and snowball sampling methods described by Martínez-Mesa et al. (2016) and McGrath et al. (2019) to select

Table 3: Determination of quantitative sample size

Category	Category population (N_c)	Proportion $f = \frac{N_c}{N}$	Category sample $n_s = f.N_c$	Final sample (Cochran's) and questionnaires distributed	Questionnaires received	Response rate (%)
Contractors NCC grade 2 (Zambian Construction Firms)	124	0.27	34	46	37	80.4
Client (Public Infrastructure-Based Institutions): Ministries, utility organizations, local authorities	135	0.30	40	51	50	98.0
Consultants-Civil/Structural (ACEZ registered firms)	88	0.19	17	33	26	78.7
Architectural Firms (ZIA registered firms)	74	0.16	12	28	24	85.7
Quantity Surveying Firms (Q.S. Registration Board)	33	0.07	2	12	10	83.3
Total	**$\sum N_c$=454**	**$\sum f$ =1**	**$\sum n_s$ =106**	**170**	**147**	**86.5**

Source: Authors

14 interview participants, considering the homogeneity of the research population (Hennink & Kaiser, 2022).

3.3. Data Collection

Data was collected from 23 June to 10 August 2022. The questionnaire sets six constructs (government, contractor, industry, project, procurement, legislation) with Likert-scale type statements indicating strategies requiring improvement and development to mitigate high construction tender price inflation. Respondents were requested to indicate their agreement to lower construction tender prices. For qualitative data, the study asks the following interview questions:

1. What is your perception regarding the significance of a tender price in a construction project?
2. What do you think are factors for developing tender prices in construction?
3. How do you think high construction tender prices affect the construction sector?
4. What challenges do you face regarding global competition and the emergence of foreign construction firms?
5. What is your experience regarding the significance of the procurement function and its contribution to the price performance of public infrastructure projects?
6. What is your understanding of current controls and their success or failures in mitigating escalating construction tender prices?
7. How can the government overcome overpricing and maintain or increase its appetite for construction projects?

3.4. Sample Techniques and Justification

In this study, purposive sampling and snowball sampling were employed to select participants for qualitative interviews. These methods were chosen to ensure the inclusion of participants with relevant expertise and direct experience in the Zambian construction sector, particularly those involved in tendering processes for public projects. The rationale for these approaches is detailed below:

Purposive Sampling was used to deliberately select participants who possess specific knowledge, experience, or insights relevant to the study's objectives. For instance, individuals such as procurement officers, project managers, and policymakers were targeted because of their direct involvement in tender price determination and management. This approach was critical in capturing nuanced perspectives on how tender prices are influenced by Zambia's unique socio-political and economic conditions, which are central to the development of the proposed model.

Snowball sampling was employed to identify additional participants through referrals from the initial purposively sampled individuals. This method was particularly useful in accessing hard-to-reach participants, such as senior government officials or construction sector consultants, who may not have been directly accessible through conventional recruitment methods. Snowball sampling helped capture a broader range of perspectives, particularly from individuals who may have insights into informal or less-documented practices that influence tender price inflation.

3.5. Data Analysis and Validation

For the questionnaire survey, mean scores were measured using a scale where 1 = strongly disagree (1.00 ≤ 1.80); 2 = disagree (1.81 ≤ 2.60); 3 = neutral (2.61 ≤ 3.40); 4 = agree (3.41 ≤ 4.20), and 5 = strongly agree (4.20 ≤ 5). Only mean score ratings above 3.5 were considered and reported as critical price management strategies. The study adopted Cronbach's alpha (α) score above 0.7, indicating a robust internal consistency of results to assess reliability for homogeneity or internal consistency of the constructs (Heale & Twycross, 2015). The study used content analysis for the interviews to transcribe, code, and group data into crucial management strategies to lower construction price inflation. For content and construct validity, the study followed the content validity index (CVI) (Zeraati & Alavi, 2014; Polit, Beck, & Owen, 2007).The study reports only items with CVI scores greater than 0.51 for fourteen respondents per the Lawshe table (Lawshe, 1975). The content validity index is calculated as follows:

$$CVR = \frac{n_e - \left(\frac{N}{2}\right)}{\left(\frac{N}{2}\right)}$$

Where CVR is the content validity ratio, n_e is the number of respondents informed of the item's essentiality, and N is the total number of respondents. The study further adopted regression analysis to predict the effects of strategy interventions on construction tender price inflation (Perneger, 2021; Lewis et al., 2011). This study utilized the Likelihood ratio test to assess the goodness-of-fit criteria for strategies for the model. All the data analysis for this study was done using the statistical package of IBM SPSS Statistics 23.0.

3.6. Model Validation

Firstly, a practical validation of the quantitative aspect of the model. The study corrected tender prices for 12 selected projects that case firms procured in 2015. The validation involved using the ordinary least square method to establish the annual optimum tender price. Secondly, a whole-model validation through a nested sampling of 20 key informants to validate the model (Goodwin et al., 2020).

3.7. Ethical Considerations

Ethical considerations were rigorously addressed to ensure the integrity of the research process and the protection of participants' rights. Participants were provided with a detailed information sheet outlining the study's purpose, objectives, and their role, alongside a consent form that explicitly stated their voluntary participation and the ability to withdraw at any stage without penalty. Confidentiality and anonymity were ensured by anonymizing data through pseudonyms or codes, supported by robust data security measures, such as password-protected files and encrypted storage. Participants were informed their insights would be used solely for academic purposes and were given the option to skip any questions they were uncomfortable answering. The study was approved by the appropriate ethical review board, ensuring compliance with research standards, and interviews were conducted with cultural sensitivity to respect the socio-political and professional contexts in Zambia. Questions were carefully framed to avoid leading or judgmental language, fostering a safe and comfortable environment for participants.

4. Findings

4.1. Qualitative Results

4.1.1 Interview Profile

All respondents were construction-project managers. Among the respondents, one had a Ph.D., two had bachelor's degrees, and eleven had master's degrees (Table 4).

The study developed an interview schedule to ascertain the level of acceptability of a construction management practice that lowers tender pricing. Table 5 shows the turnaround strategies developed through the CVR scores. Findings reveal that thirteen attributes exhibited significant Lawshe content validity scores above 0.51.

4.2. Quantitative Results

The study utilized the goodness-of-fit criteria to determine how well the sample data represented the population. Table 6 summarizes the goodness-of-fit criteria and shows that the chi-square test of the null hypothesis that the coefficients are different from zero

Table 4: Participants for research interviews

Description	Participant ID	Academic qualification	Area of expertise/Years of practice
Purposive participants	PS1	Bachelor of Engineering (Civil & Environmental Engineering)	Civil engineering consultant/22 years
	PS2	MSc Project Management	Contractor/18 years
	PS3	MSc (Construction Management & Economics)	Quantity surveying and construction management/40 years
	PS4	Bachelor of Engineering (Civil & Environmental Engineering)	Civil Servant/Public Infrastructure-Based Institution/27 years
	PS5	MSc Business Management Bachelor of Engineering (Civil Engineering)	Contractor/17years
	PS6	MEng Construction Management BSc Architecture	Architectural consultant/15years
	PS7	MSc Project Management BSc Building Science	Quantity surveying consultant/25years
	PS8	MSc Architecture PGDip. Project management and Building Law BSc Architecture	Architectural consultant/30years
	PS9	MSc Logistics & supply chain management BSc Procurement management Dip. Chartered Institute of Purchasing & Supply	Civil Servant/Public Infrastructure-Based Institution/22years
Snowballing participants	SS1	Ph.D. (Transportation Economics) MEng Civil (Pavement & Transportation) BEng Civil & Environmental Engineering	Public project financing/24years
	SS2	MEng Civil (Pavement Design) BEng Civil & Environmental Engineering	Civil engineering consultant/30years
	SS3	MEng Construction Management BEng Civil & Environmental Engineering	Civil engineering consultant/25years
	SS4	MEng Project Management BEng Civil & Environmental Engineering	Contractor/22years
	SS5	MSc Construction Management BSc Quantity Surveying	Quantity surveying consultant/35years

Source: Authors

Table 5: Turnaround management strategies

No. of participants	Participants' I.D.	Turnaround practices from Expert Quote	Sector group	Lawshe value (CVR)
12	PS1, PS2, PS3, PS4, SS2, PS6, SS3, PS7, SS4, PS8, SS5, PS9	1. Develop funding projections and ensure readily available funds 2. Guarantee availability of project funding 3. Control interest, value-related, and time-related costs 4. Ensure timely payment to contractors	1. Government	*0.71
12	SS1, SS2, PS6, SS3, PS8, SS1, PS7, PS9, PS5, SS4, PS2, PS3	5. Develop well-informed cost estimates. 6. Plan and design execution of projects. 7. Utilize various professionals to develop cost norms and value engineering	2. Contractor	*0.71
11	PS2, PS3, SS3, PS7, PS8, PS9, SS1, PS4, SS4, SS5, PS5	8. Prepare project plans with robust designs and costing	3. Project	*0.57
12	PS1, PS4, SS2, PS5, PS8, PS9, PS7, SS1, PS8, SS3, PS6	9. Ensure that control systems like the e-GP and materials price index are realistic. 10. Hire experienced consultants early enough in the project stages	4. Procurement	*0.71
13	PS3, PS7, SS1, PS8, SS3, PS7, PS8, PS1, SS1, SS2, SS3, PS8, SS5	11. Develop models for rate build-up 12. Produce indices timely 13. Avoid the "text-book" approaches	5. Industry 6. Legal	*0.85

Source: Authors

is insignificant. Nagelkerke's R^2 is close to 1.000 at 0,773, demonstrating the strategies' better-fit of the model. The Pseudo R^2 indicates that the multinomial model explains 62.5% only of the inflation between the independent variables and construction tender price inflation.

Table 6: Goodness-of-fit and Pseudo R-Square

Goodness-of-Fit				Pseudo R-Square (R^2)	
	Chi-Square	**df**	**Sig.**	Cox and Snell	0.625
Pearson	131.539	152	0.883	Nagelkerke	0.773
Deviance	91.397	152	1.000	McFadden	0.593

Source: Authors

Table 7: Classification

Observed	**Predicted**			
	3	4	5	Percent Correct
3	9	0	0	100.0%
4	0	31	15	67.4%
5	0	5	87	94.6%
Overall Percentage	6.1%	24.5%	69.4%	86.4%

Source: Authors

Table 7 indicates that the estimated multinomial regression functions correctly classify 86.4% of the model.

Table 8 (In Appendix) shows the results of the tender price management strategies (data sets), including areas requiring improvement and development. The analysis indicates that the data sets have mean values ranging from 3.96 (lowest mean of the data set) to 4.49 (highest mean of the data set). These results indicate that the respondents agreed that specific strategies could yield manage construction tender price inflation. Based on the chi-square ranking, the top strategies included in the model development are GD10, CD1, CD5, ID9, ID14, ID8, PD12, PD10, PD1, and MD3. Of these, those with the highest likelihood ratio were CD1 (13.675), CD5 (10.972), and PD12 (8.610). All strategies had a Cronbach's alpha of 0.988. This implies that the instrument used to measure the effects of construction tender price inflation is highly reliable.

5. Discussions

The findings of this study offer important insights into the dynamics of tender price inflation in public construction projects, particularly in the Zambian context. These results contribute to the understanding of tender pricing by highlighting the complex interplay between economic factors (such as inflation, interest rates, and exchange rate) and socio-political influences (such as governance, regulatory frameworks, and political stability). In line with the literature, the study reaffirms that both sets of factors significantly shape tender price variability, which is critical for project planning and cost management. Previous research, such as the works of Wong & Ng (2010) and Yiu & Tam (2006), emphasized forecasting tender price indices and understanding economic drivers. However, this study extends beyond those models by incorporating qualitative socio-political dimensions, as suggested by Zhang et al. (2006), who identified gaps in existing risk management theories that fail to account for realistic socio-political factors. This broader approach provides a more comprehensive model, particularly suited to volatile markets like Zambia's, where economic uncertainty and political instability frequently impact public projects.

The findings also reveal that predictability and risk management are critical for mitigating tender price inflation. The literature highlights the importance of cost certainty for project stakeholders (as discussed by Laryea & Hughes, 2008), and this study supports those findings by showing that projects with lower variability in tender price outputs enable better budgeting, resource allocation, and risk management. The emphasis on cost certainty and risk mitigation strategies, such as the integration of project management practices with accurate forecasting techniques, aligns with the broader theoretical frameworks of tender price control in construction management. Furthermore, the study contributes to existing literature by proposing a model that effectively balances both economic and socio-political factors, addressing a gap in the current understanding of tender price inflation management. Previous models, like those developed by Olatunji (2008) and Ho (2013), focused heavily on economic predictions but lacked adaptability to socio-political changes. This study's model rectifies that limitation, offering a context-specific framework that can adapt to the political and economic realities in Zambia's public construction sector. The results of this study provide valuable contributions to both theory and practice, enhancing the understanding of tender price management in public construction projects. By integrating economic and socio-political factors, the proposed model addresses key limitations in previous approaches, offering a more holistic framework for managing tender price inflation in volatile markets.

The findings of this study align with institutional and risk management theories, which emphasize the importance of robust governance structures and adaptive policies in mitigating systemic risks such as tender price inflation. Institutional theory highlights how formal rules and norms—such as procurement regulations and anti-corruption measures—shape organizational behavior. In the Zambian context, the absence of standardized tender price management frameworks has perpetuated inefficiencies and opportunistic behaviors in public construction projects. By aligning policy recommendations with institutional theory, this study advocates for the establishment of transparent and enforceable procurement guidelines that address governance deficiencies. For example, strengthening regulatory oversight and mandating the use of historical data for tender price estimation can mitigate the risks associated with cost overruns and unpredictable price inflation.

Furthermore, risk management theories underscore the need for dynamic models that incorporate both quantitative and qualitative factors to enhance decision-making under uncertainty. The proposed tender price management model integrates socio-political and macro-economic variables, offering a practical tool for policymakers to forecast and stabilize tender prices. This aligns with the theoretical perspective that effective risk management relies on proactive identification and mitigation of vulnerabilities. Policy implications, such as creating real-time monitoring systems for exchange rates and inflation trends, would not only operationalize this model but also promote data-driven decision-making. These measures, combined with targeted capacity-building initiatives for procurement officers, provide a sustainable pathway for improving public sector efficiency and ensuring the timely delivery of essential infrastructure projects in Zambia.

5.1. Implications of Qualitative Results

Based on a high content validity ratio, the study identifies a possible range of existent and non-existent practices for mitigating construction tender price inflation that includes planning the execution of projects, developing funding projections, guaranteeing the availability of project funding, controlling interest, value-related and time-related costs, and hiring experienced consultants early enough in the project stages. Other practices include developing well-informed cost estimates, avoiding "text-book" approaches when developing price indices, ensuring timely payment to contractors, and preparing project plans with robust designs and costing. The study further interlinks turnaround practices into construction sector groupings. The objective of mitigating construction tender price inflation is achievable through achieving institutional goals. Six sector groups are identified as areas of responsibility for managing tender price inflation: government, procurement function, legal function, project, and industry.

5.2. Implications of Quantitative Results

Based on the goodness of fit criteria (Chi-squared test), the results suggest that adopting innovative systems, improving technical abilities, developing resource capabilities, mitigating risk factors at inception, mitigating project costs, upholding project duration specifications, removing industry uncertainties, and instilling sector confidence are critical tender price controls for successfully implementing an economically sustainable construction sector. Other essential tender price controls include legislating rate analysis and ensuring the presence of experienced consultants. The findings of the statistical study of the quantitative data indicate a strong correlation between the independent variables and construction tender price. Regression functions correctly classify 86.4% of the inflation effect of tested predictor variables on construction tender price. The study evidences a more significant influence of independent variables on tender price.

5.3. Model Development

The paper develops an integrated model (Figure 2) that mathematically and categorically describes the beliefs about construction tender prices. However, mathematical modeling for optimal construction tender price requires elements of compromise since the majority of interacting variables are far too complicated. The first level of compromise includes identifying the most critical factors affecting tender pricing. The second level of compromise includes selecting the type and amount of meaningful mathematical manipulation. The mathematical model developed in this paper is applicable in several scenarios depending on the state of knowledge about tender-price inflation, including enhancing scientific understanding of the phenomenon through quantitatively expressing existing knowledge and supporting strategic and tactical decisions made by managers and planners.

The descriptive aspects of the model allow more informed decision-making that guides the management of public infrastructure projects. The element is critical for developing project management analytics for institutions to make better decisions and improve the performance of tender prices by identifying trends and patterns. This aspect helps the production of key performance indicators and metrics for public infrastructure projects regarding tender construction price. Thus, this aspect focuses on the prominence of patterns observable in historical and current information.

4.1.1 The Analytical (Quantitative) Aspect of the Model

The analytical aspect of the model presents a closed-form solution to equations describing changes to construction tender-price expressed in a mathematical analytic function. The quantitative nature of the analytical characterization is crucial for making specific decisions regarding the reliability of engineers' estimates and the performance of the related strategies. The study expresses the analytical aspect of the model with sufficient precision to allow formal and reliably supported analysis. The dynamic analytical element represents the time-varying state of construction tender prices. For this paper, a model simulates the execution based on actual conditions. It allows the model to recreate simulations on instances related to the simulation environment. The model further applies actual initial conditions of the cases and later uses mathematical equations to determine changes as a function of specific independent variables.

4.1.2 Model Assumption

This paper assumes that, without other limiting and encouraging factors, tender pricing is positively proportional to interest rate, exchange rate, inflation rate, foreign direct investment, and national debt. A mechanistic or empirical model, which describes such a price in construction infrastructure projects, is an equation of the form:

$$Y : f(I + R + E + Fdi + D) \text{.........} \quad \text{[Equation 1]}$$

Where Y is the construction tender price, which is the dependent variable, the independent variables consist of I (inflation rate), R (interest rate), E (Exchange rate), D (Government debt), and Fdi (Foreign direct investment). The study utilizes statistical processes to estimate the relationship between construction tender price and the independent variables in this modeling. The study proposes a regression model of the form:

$$Y_i = f(X_i, \beta) + e_i \text{.......................} \quad \text{[Equation 2]}$$

Y_i is a function of X_i and β in which e_i represents an additive error representing un-modeled determinants of Y_i. The study proposes a simple multivariate regression to estimate the function $f(X_i, \beta)$ of the form:

$$Y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + e_i \text{……………[Equation 3]}$$

The form represents a reasonable approximation of the statistical process and a convenient form for the function $f(X_i, \beta)$. The study utilizes the proportion of variance (R-Squared) values describing the relationship of each independent variable with construction tender price. Table 9 shows that the polynomial regression with the highest R-Squared values represents the optimum effect on tender price.

The standard form of the adopted polynomial function is:

$$f(x) = \beta_n x^n + \beta_{n-1} x^{n-1} + \ldots\ldots + \beta_2 x_i^2 + \beta_1 x_i + \beta_0$$
….. [Equation 4]

Where β_n and βn-1 are real number constants, β_n cannot equal zero, and n is a non-negative integer. In this function, all exponents of the variable are whole numbers. However, this is still a linear regression despite quadratic expression in the independent variable. The function is linear in the parameters β_0, β_1, and β_n. The straight-line case thus suffices, given a random sample from the population, in estimating the population parameters through a linear regression model:

$$y_i = f(Inflation + Interest + forex + Fdi + Debt) + \varepsilon_i$$
…… [Equation 5]

Table 10 summarizes the variables used in multinomial regression analysis. The variable values are annual averages, which may affect the significance and prediction level of the model. However, the research is in accordance with and appropriate to regression model development.

Table 11 shows the model variables, summary, and analysis of variance. The analysis further presents respective means and standard deviations for valid observations for all 11 and 10 case studies. Where ε_i

Table 9: Model function and regression for upgrading roads to bituminous standards

Independent Variable	Model	Regression type	The proportion of variance R-squared (R^2)	Optimum effect on the tender price
Forex rates	$y = 2.7471e^{0.1041x}$	Exponential	$R^2 = 0.5371$	• polynomial
	$y = 0.8295x + 1.1566$	Linear	$R^2 = 0.6864$	
	$y = 9.4795\ln(x) - 11.489$	Logarithmic	$R^2 = 0.7576$	
	$y = -0.0642x^2 + 2.4333x - 7.1354$	Polynomial	$R^2 = 0.7671$	
	$y = 0.4939x^{1.2466}$	Power	$R^2 = 0.6508$	
Inflation rates	$y = 4.4337e^{0.0573x}$	Exponential	$R^2 = 0.1928$	• polynomial
	$y = 0.429x + 5.2757$	Linear	$R^2 = 0.2175$	
	$y = 5.2137\ln(x) - 1.9979$	Logarithmic	$R^2 = 0.2092$	
	$y = 0.0116x^2 + 0.1117x + 7.0459$	Polynomial	$R^2 = 0.2195$	
	$y = 1.5518x^{0.7304}$	Power	$R^2 = 0.204$	
Interest rates	$y = 0.4707e^{0.1238x}$	Exponential	$R^2 = 0.4918$	• polynomial
	$y = 0.9338x - 11.672$	Linear	$R^2 = 0.563$	
	$y = 20.387\ln(x) - 53.797$	Logarithmic	$R^2 = 0.5577$	
	$y = -0.0169x^2 + 1.6895x - 19.849$	Polynomial	$R^2 = 0.5645$	
	$y = 0.0019x^{2.6761}$	Power	$R^2 = 0.4774$	
External Debt (U.S. $ 'Bn)	$y = 2.8732e^{0.1077x}$	Exponential	$R^2 = 0.7576$	• polynomial
	$y = 0.8043x + 2.0486$	Linear	$R^2 = 0.8503$	
	$y = 4.5114\ln(x) + 0.999$	Logarithmic	$R^2 = 0.7346$	
	$y = 0.0046x^2 + 0.7199x + 2.2958$	Polynomial	$R^2 = 0.8509$	
	$y = 2.1598x^{0.6767}$	Power	$R^2 = 0.8209$	

Source: Authors

Table 10: Summary of variables

Case	Year	Tender price (ZMW'million/km)	Forex rates	Inflation rates	Interest rates	FDI (U.S. $ 'Bn)	External Debt (U.S. $ 'Bn)
Upgrading of roads to bituminous standards	2008	1.438825829	4.2	12.5	19.1	0.94	0.91
	2009	1.811932233	4.9	13.4	22.1	0.69	2.25
	2010	1.373748439	4.8	8.5	20.9	1.73	1.72
	2011	2.684805086	7.3	8.7	18.8	1.11	1.68
Valid N (listwise) = 11	2012	4.599107964	5.14	6.6	19.1	1.73	0.92
	2013	4.690770679	5.39	7	16.3	2.1	2.13
	2014	4.260340586	6.15	7.8	18.7	1.51	5.02
	2015	6.874454978	8.63	10	21.1	1.58	8.08
	2016	7.053690932	10.31	18.2	28.1	0.66	9.21
	2017	8.706679835	9.54	6.6	26.9	1.11	12.45
	2018	14.39574954	10.45	7.5	24	0.41	12.1
	Mean	5.263	6.9827	9.709	21.373	1.2336	5.1336
	Std.	3.888	2.36470	3.6231	3.6519	0.53474	4.51533
Periodic maintenance of feeder roads	2012	0.162880317	5.14	6.6	19.1	1.73	0.92
	2013	0.690114967	5.39	7	16.3	2.1	2.13
	2014	0.466011329	6.15	7.8	18.7	1.51	5.02
	2015	0.58755172	8.63	10	21.1	1.58	8.08
Valid N (listwise) = 10	2016	0.878497449	10.31	18.2	28.1	0.66	9.21
	2017	1.43244782	9.54	6.6	26.9	1.11	12.45
	2018	1.405497777	10.45	7.5	24	0.41	12.1
	2019	1.20648096	12.91	9.1	25.6	0.55	15.05
	2020	1.555681335	18.28	15.7	26.8	-0.17	16.45
	2021	1.623899147	20.05	22.1	25.7	0.19	17.7
	Mean	1.001	10.6850	11.060	23.230	9.9110	0.9670
	Std.	0.51196	5.11445	5.5670	4.1148	5.87104	0.74772

Adapted from Tembo *et al*. (2023a)

is an error term and subscript $_i$ indexes a specific observation. $\ell_i = y_0 - y_i$, is the residual or the difference between the predicted value of the construction tender price and its actual value. The regression coefficients of the model, as shown in Table 10, indicate an R-Squared value of 0.742. Macroeconomic indicators under study explain at least 74.2% of the variance of the construction tender price.

The analysis of variance summarizes information regarding multiple correlations to test the significance of the model regarding the extent to which asset of macroeconomic indicators (independent variables) predict construction tender prices (Table 12). The Sig. column represents the *p*-value for the test of significance of the model and, in the case *p*<0.05 for a *p*-value of 0.028, so the set of indicator variables is significantly related to construction tender prices.

The other columns provide the details of how the *p*-value is determined. The sum of squares for regression (26.334) is the mean of the square for regression. The sum of squares labeled residual (19.480) is the sum of

Table 11: Model Summary

Model	Case study	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	Upgrading of roads to bituminous standards	0.933[a]	0.871	0.742	1.9739
	Periodic maintenance of feeder roads	0.927[a]	0.859	0.683	0.2882
a. Predictors: (Constant), External Debt (U.S. $ 'Bn), Inflation rates, FDI (U.S. $ 'Bn), Interest rates, Forex rates					

Source: Authors

Table 12: Analysis of variance

Model[a]		Sum of Squares	df	Mean Square	F	Sig.
Upgrading of roads to bituminous standards	Regression	131.670	5	26.334	6.759	.028[b]
	Residual	19.480	5	3.896		
	Total	151.150	10			
Periodic maintenance of feeder roads	Regression	2.027	5	.405	4.879	.075[b]
	Residual	.332	4	.083		
	Total	2.359	9			

a. **Dependent Variable: Tender price (ZMW'million/km)**
b. **Predictors: (Constant), External Debt (U.S. $ 'Bn), Inflation rates, FDI (U.S. $ 'Bn), Interest rates, Forex rates**

Adapted from Tembo *et al*. (2023a)

differences between the predicted values and the actual values of y, which is the sum of squared deviations of the data around the regression line. The square root of the variance of residuals, 3.896, is 1.974, which is the standard error of the estimate. To estimate the regression equation, the coefficients table, Table 13 presents the least squares estimates of the intercept and slope of the regression line. Five values of regression weights (b, 0.638, -0.241, -0.334, -1.561, 0.577) are listed in column headed B, while the regression intercept is (a, 9.255). Respectively, the equation of the least squares is the therefore:

$$y = 9.255 + 0.638x_1 - 0.241x_2 - 0.334x_3 - 1.561x_4 + 0.577x_5 \ldots \text{[Equation 6]}$$

In which x_1 = forex rates, x_2 = inflation rate, x_3 = interest rates, x_4 = FDI and x_5 = government debt.

- Validation of analytical aspect

The study corrected tender prices for 12 selected projects that case firms procured in 2015. Table 14 lists the selected contracts. Table 15 shows the utilization of the ordinary least square method to establish the annual optimum tender price for the year 2015 and OLS-generated coefficients.

The independent variables include inflation rate (10), the foreign exchange rate (8.63), foreign direct investment (U.S. $1.58 billion), External government debt (U.S. $8.08 billion), and interest rate (21.1). To illustrate, the computer-generated OLS equation ($Y = 9.255 + 0.638x_1 - 0.241x_2 - 0.334x_3 - 1.561x_4 + 0.577x_5$) determines the optimum tender price for the year 2015 to be ZMW7,499,320.00/km. By illustration, three factors, road length, price per kilometer, and annual optimum tender price, are later used to generate the

Table 13: Regression coefficients

Model[a]		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
Upgrading of roads to bituminous standards Periodic maintenance of feeder roads	(Constant)	9.255	8.105		1.142	.305	-11.581	30.091
	Forex rates	.638	.699	.388	.913	.403	-1.158	2.435
	Inflation rates	-.241	.262	-.225	-.920	.400	-.915	.433
	Interest rates	-.334	.385	-.314	-.868	.425	-1.325	.656
	FDI (US $'Bn)	-1.561	1.661	-.215	-.940	.390	-5.831	2.709
	External Debt (U.S. $ 'Bn)	.577	.447	.670	1.290	.253	-.573	1.727
Upgrading of roads to bituminous standards	(Constant)	.145	1.785		.081	.939	-4.812	5.101
	Forex rates	.022	.105	.222	.210	.844	-.270	.315
	Inflation rates	-.018	.043	-.201	-.430	.689	-.138	.101
	Interest rates	.007	.063	.057	.111	.917	-.168	.182
	External Debt (U.S. $ 'Bn)	.068	.079	.775	.854	.441	-.152	.287
	FDI (U.S. $ 'Bn)	-.010	.389	-.015	-.027	.980	-1.089	1.069

a. Dependent Variable: Tender-price (ZMW'million/km)

Adapted from Tembo *et al*. (2023a)

tender-price error (error =L (P-Y) as shown in Table 13. As a case in point, a negative error indicates a low tender price, while a positive error indicates a high tender price. Notably, the bid for upgrading Selected urban roads (20.02km) to the Bituminous standard of Mkushi in the Central Province indicated a tender price of ZMW123,142,060.36. The analysis in Table 15 shows the negative tender-price error of ZMW28,344,203.64.

Consequently, this is a low-priced bid such that the corrected tender price shows an upward adjustment to ZMW151,486,264.00. Whereas, the bid for upgrading of selected urban roads (9.6km) to the bituminous standard of Zambezi in the Northwestern Province by Roads and Paving Ltd at a tender price of ZMW129,403,184.05 gives a positive tender-price-error of ZMW57,409,712.05. The corrected tender price arising from this high-priced bid is ZMW71,993,472.00.

4.1.3 Descriptive (Qualitative) Aspect of the Model

The descriptive aspect of the model allows public institutions to monitor trends and track tender-pricing goals. Public institutions can utilize the descriptive aspect of performance in different strategies (strengths and weaknesses). Correspondingly, this aspect allows for generating results and obtaining long-term benefits through effective continuous improvement.

4.1.4 Descriptive of Model Components

Brief descriptions of each component of the model are as follows:

Tender-price level: This is the annual average of the previous year's tender prices per kilometer (in the case

Table 14: List of contracts reviewed

S/N	Contract name	Length (Km)	Contract sum (Zmk)	Award date
1	Upgrading of Isoka – Muyombe- Chama- Lundazi Road to Bituminous Standard in Eastern Province of Zambia Lot 4 (Muyombe Road Junction) to Lundazi (Km40+000 on D103) to (84 km)	84	585,556,978	December 2015
2	Upgrading of Isoka – Muyombe – Chama - Lundazi Road to Bituminous Standard in Eastern Province of Zambia Lot 5 (Muyombe Road Junction) to Lundazi (Km40+000 on D103) to (84Km)	84	417,108,471	December 2015
3	Construction of Mazabuka Bypass road	5	57,014,787.00	2015
4	Upgrading of Isoka – Muyombe – Chama - Lundazi Road to Bituminous Standard in Eastern Province of Zambia Lot 5 (Muyombe Road Junction) to Lundazi (Km40+000 on D103) and 15Km of Lusuntha	56	417,108,471.29	2015
5	Upgrading and realignment of Nakonde-Kanyala-Sansamwenje Road (M14/RD69)	83.9	367,218,609.29	2015
6	Upgrading of Nsemuka via Kayambi to Chozi to D001, including 18km from Chimba to Chitimukulu and 35km of selected urban roads in Mungwi District Lot 2	82	631,194,336.31	2015
7	Upgrading of Selected urban roads (15km) to Bituminous standard of Sinda in the Eastern Province	15	123,936,213.56	March 2015
8	Upgrading of Selected urban roads (20.02km) to the Bituminous standard of Mkushi in the Central Province	20.02	123,142,060.36	2015
9	Upgrading of Selected urban roads (11.4km) to the Bituminous standard of Kapiri Mposhi in the Central Province	11.4	109,660,183.91	2015
10	Upgrading of Selected urban roads (9.27km) to the Bituminous standard of Kasempa in the Northwestern Province	9.27	115,405,395.11	March 2015
11	Upgrading of Selected urban roads (20.5km) to the Bituminous standard of Solwezi in the Northwestern Province	20.5	220,867,715.90	March 2015
12	Upgrading of Selected urban roads (9.6km) to the Bituminous standard of Zambezi in the Northwestern Province	9.6	129,403,184.05	March 2015

Source: Authors

Table 15: OLS corrected tender price for each reviewed contract

S/N	Variable	Value = X	Regression coefficient (Rc)		Weighting = RcX (ZMW/Km)	
-	intercept	-	9.255		9.255	
1	Forex rates	8.63	0.638		5.50594	
2	Inflation rates	10	-0.241		-2.41	
3	Interest rates	21.1	-0.334		-7.0474	
4	FDI (US $'Bn)	1.58	-1.561		-2.46638	
5	External Debt (U.S. $ 'Bn)	8.08	0.577		4.66216	
2015 Annual optimum tender price (Y)		$Y = 9.255 + 0.638x_1 - 0.241x_2 - 0.334x_3 - 1.561x_4 + 0.577x_5$			7,499,320.00	
Length (Km) = L	Tendered Price (T.P.) ZMW	Price = (P) ZMW/Km	P-Y	error (e) = L(P-Y)	Comment on the tender price	Corrected TP = TP-e ZMW
84	585,556,978.00	6,970,916.40	(528,403.60)	(44,385,902.00)	low	629,942,880.00
84	417,108,471.00	4,965,577.04	(2,533,742.96)	(212,834,409.00)	low	629,942,880.00
5	57,014,787.00	11,402,957.40	3,903,637.40	19,518,187.00	high	37,496,600.00
56	417,108,471.29	7,448,365.56	(50,954.44)	(2,853,448.71)	low	419,961,920.00
83.9	367,218,609.29	4,376,860.66	(3,122,459.34)	(261,974,338.71)	low	629,192,948.00
82	631,194,336.31	7,697,491.91	198,171.91	16,250,096.31	high	614,944,240.00
15	123,936,213.56	8,262,414.24	763,094.24	11,446,413.56	high	112,489,800.00
20.2	123,142,060.36	6,096,141.60	(1,403,178.40)	(28,344,203.64)	low	151,486,264.00
11.4	109,660,183.91	9,619,314.38	2,119,994.38	24,167,935.91	high	85,492,248.00
9.27	115,405,395.11	12,449,341.44	4,950,021.44	45,886,698.71	high	69,518,696.40
20.5	220,867,715.90	10,774,034.92	3,274,714.92	67,131,655.90	high	153,736,060.00
9.6	129,403,184.05	13,479,498.34	5,980,178.34	57,409,712.05	high	71,993,472.00

of a road project, as is the case with this study). Therefore, the tender-price level is a suppositious measure of inclusive prices for an actual construction good or service set.

Tender-price improvement barriers include barriers to implementing adequate tender-price management controls, such as unrealistically low prices, corruption, poor documentation, and resistance to change.

Economic indicators or quantitative variables include measures of a country's macroeconomic performance, such as GDP, government debt, inflation, exchange rate, government budget, international trade, investment, prices, and balance of payments.

The ordinary Least Squares regression (OLS) method is a mathematical technique for estimating economic indicators' coefficients. It utilizes linear regression equations to describe their relationship with tender price.

Technical assistance: Technical assistance in obtaining targeted support from organizations or consultants with developmental knowledge regarding tender-price indices or identifying statistically applicable quantitative-independent variables.

Tender-price-level objectives are goals a public institution establishes to meet the central governments' and other stakeholders' construction tender-price needs and expectations.

Tender-price negotiations: This requests a better price, additional value formation, and favorable terms between the client and potential contractor.

Tender-price management practices: These are formal processes, working methods, innovations, work systems, and activities developed by public institutions to guide effective tender-price management direction and actions to influence and improve the behavior of tenderers. This study indicates that these shall be within the dominions of strategies related to the central government, procurement, existing legal framework, contractors, industry, and projects.

Tender-price management outcomes: Includes expected results that motivate price management practices and continual improvement.

Tender-price monitoring: This is a process of gathering intelligence through analysis and determination of tender-price internal and external variables to optimize management strategies and practices.

Tender-price evaluation: A process of evaluating the effectiveness and performance of tender-price management strategies and practices through identifying key performance indicators critical for successfully optimizing tender prices.

Tender-price improvement: A process of developing corrective and preventive actions through identifying causes to ensure the execution of public projects with even better prices than the best-quoted sector prices.

Tender-price controls: A set of actions that serve as a guideline for tender-price strategy implementation. These may include such things as formal tender-price documentation.

Tender-price rationalization: Changing the price level by ensuring a more goal-oriented pricing system centered on specific rules.

Validation of engineer's estimates: Certifying the accuracy of project cost estimates by verifying information and methods utilized during estimation.

Continual improvement: An ongoing process of continuously improving tender prices by seeking incremental, breakthrough improvements and other opportunities focusing on directing and concentrating effort.

4.1.5 The Distinctiveness of the Model

The model shows similarities to other developed models and their components, such as the model by Olatunji (2008). The study focuses on the conceptual development of the model that accentuates how to revise and refine algorithms to improve the degree of automation of bid data and results accuracy. Although the model shows statistical invalidity for small sample sizes (due to the use of averages in this example), it does not involve solving complex equations and is less time-consuming. The model allows for continuous improvement due to its easy incorporation of new information. It gives the model unlimited prediction capabilities while accounting for various correlations between volatilities.

Moreover, the model quickly forecasts accumulated time series and accounts for the effects of extant price levels while accounting for the sociopolitical strategies of public project implementation. Based on the conceptual framework in Figure 2, the proposed model consists of two integrated components. The model is helpful to clients (mainly public institutions), contractors, and consultants in bridging contemporary gaps regarding tender price inflation.

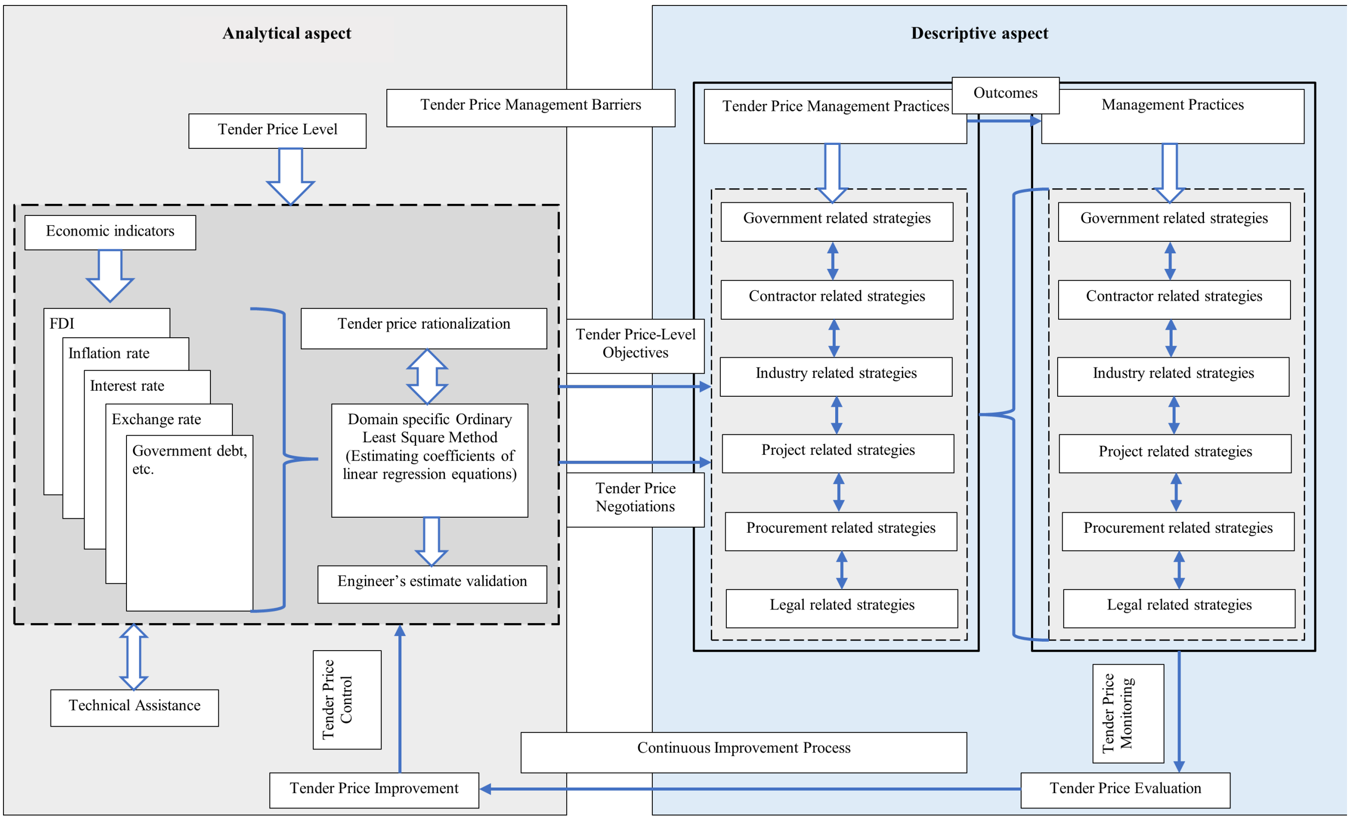

Figure 2: Proposed Integrated Model for Tender-Price Management
Source: Authors

Table 16: Background information of respondents

Category of Practice	Frequency	Percentage
Client (Public Sector)	9	47.37
Consultant	6	31.58
Contractor	4	21.05
Total	19	100

Source: Authors

4.1.6 Model Validation

The study utilized nested sampling to determine a sample size of 20 critical informants to validate the model. Of the 20 key informants, only 19 returned the online questionnaire, bringing the response rate to 95%. Accordingly, a high nested response rate for this study is essential as representativeness affects the validity of findings (Goodwin et al., 2020). Table 16 shows that 47.37% of critical informants characterize clients in the public sector, with consultants (31.58%) and contractors (21.05%).

Table 17 shows that the results of the validation exercise are probably reliable due to low standard deviations (between 0.496 and 0.653) obtained across critical validation elements. Based on normal distribution, 70% of these observations lie within one standard deviation of their mean. Overall, the results show a mean of 3.35 and a 0.57 standard deviation across all model price management and implementation elements. This indicates that 68% of experts in the industry agree that the model is client-focused, inspires stakeholder engagement, facilitates the process and information-based decision-making, and improves tender-price management. Regarding the focus of the tender-price management model, results show a mean of 2.95 and a standard deviation of 0.62. Only 30% of industry experts disagree that the model is client-focused.

However, the model shows effective stakeholder engagement with a mean of 3.26 and a standard deviation of 0.65. It reflects 70% of an effective stakeholder-engagement structure within the Zambian public construction sector on the improvement of tender-price management, a higher mean of 3.32 and a standard deviation of 0.58. 68% of experts agree the model offers some intrinsic improvements to tender-price management in public infrastructure delivery. It establishes that all responses are statistically significant at $p<0.05$, echoing a high standard of validity, acceptability, and usefulness.

In identifying factors affecting the implementation of the model, key informants reveal the following:

1. Lack of mechanisms for working out costs from basic prices.
2. Failure by state institutions to make adequate budget provisions.
3. Procurement-related problems and
4. Failure to ring-fence project funds.

The key experts recognized the following considerations for the functionality of the model:

1. Foreign contractors must increase knowledge and equipment ownership transfer as they participate with local firms that may not have technical and equipment capacity.
2. The government should encourage or form construction sector banks with lower borrowing rates to support the local construction companies.
3. Need to develop solicitation documents that respond to the needs of clients/owners.
4. The procurement staff of the client/owner must be fully knowledgeable of construction project management.
5. Project monitoring should be encouraged through clients' M&E teams. Must develop an award-and-penalty regime for those who comply, exceed requirements, and fail to comply.

The paper discusses the study's results on construction tender-price management and attempts to rationalize perceived rising construction tender prices in Zambia. The discussion considers other literal research findings, construction experts in the sector, and documentary reviews. The debate emphasizes three inherent results:

1. There is a need to identify and manage country-specific factors affecting construction infrastructure management.
2. There is a need to identify and weave together industry-specific strategies for addressing tender-price inflation and perceived inflation.
3. The model developed by this study needs to be adopted because of its unlimited prediction capabilities and implementation flexibility.

Table 17: Implementation of the tender-price management system

S/N	Critical elements of the validation exercise	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	Mean	Std. Deviation	Std. Error Mean	t	Sig. (2-tailed)
1	Implementation of the model is client-focused	15.79	63.16	21.05	0	2.95	0.621	0.143	20.679	0.000
2	Implementation of the model enables the engagement of industry players	36.84	52.63	10.53	0	3.26	0.653	0.150	21.770	0.000
3	The model enables a process-based approach	63.16	36.84	0	0	3.63	0.496	0.114	31.941	0.000
4	The model is an improvement on tender-price management systems	36.84	52.63	5.26	0	3.32	0.582	0.134	24.817	0.000
5	The model enables evidence-based decision making	57.89	42.11	0	0	3.58	0.507	0.116	30.754	0.000
***1 = strongly disagree … 4 = strongly agree *Valid N (listwise) = 17 *Significant at p<0.05**										

Source: Authors

6. Conclusion

The model integrates analytical (quantitative features based on economic factors) and descriptive (qualitative characteristics based on sociopolitical factors) aspects of tender-price inflation. The combined quantitative factors and variables utilize the equations of ordinary least squares (OLS) to determine an optimum domain-specific tender price, while the qualitative base integrates sociopolitical strategies. Combining the two platforms provides the model with a low inflation tender-price output. The model is versatile and adaptable. The quantitative aspect of the model does not require any external content management systems (CMSs) and is programmable to support web-based solutions. The model requires comprehensive data collection regarding public construction projects to establish a database or an information management system. The model functions correctly in both validation steps, as the corrected tender price obeys operational principles set out in the assumptions. It confirms that further investigations into the model behavior are not necessary. However, the model requires many datasets to guarantee improvement in its tender-price prediction and statistical significance of input variables.

The study's findings have significant implications for practice in the construction industry. First, the proposed model, with its low variability in tender price outputs, offers a tool for enhanced cost predictability. This allows contractors, clients, and project managers to forecast project costs with greater accuracy, leading to more efficient resource allocation and improved financial planning. Additionally, by addressing both economic and socio-political factors, the model provides a comprehensive strategy for managing price fluctuations, which is critical in markets where political and economic instability often disrupt construction projects. Moreover, the study's focus on risk management strategies—such as incorporating market dynamics into price modeling and enhancing procurement processes—demonstrates practical ways to mitigate tender price inflation. These insights could influence policy reforms in the public sector, ensuring more transparent and stable governance practices in the tendering process. For industry professionals, the findings underscore the importance of developing flexible pricing strategies that account for both internal project conditions and external economic forces, fostering more sustainable construction practices in Zambia and similar developing economies.

7. Recommendations

Based on conclusions, the main recommendation of this study include:

1. Compulsory use of engineer's estimates.
2. Adoption of the integrated model for public sector construction management.
3. Establishment and updating of domain-specific databases or information management systems for variables.
4. Calibration of the model for use in specific type and nature of project or work description thereof.

8. Limitations

When interpreting the findings, consider the following limitations of the study:

1. The analytical aspect of the model (OLS equations) developed from case firms evaluates, in particular, two leading performance indicators on road infrastructure: length (Km) and tender price (Zambian Kwacha - ZMW).
2. The lack of detailed project data from case firms led to the use of limited factors such as length and tendered prices only. More specific information regarding road width, layer thickness, loading capacity, number and type of culverts, and number and type of bridges would have permitted better project categorization for analyzing more similar projects and significantly improved model prediction. However, the study took caution in using such available data to successfully demonstrate the model's operational principles.
3. The analytical aspect of the model, specifically the OLS equations, is limited to road sector information obtained from case firms. Thus, the study findings only apply to other projects after developing domain-specific OLS equations. It requires more refined categorization regarding the type of project, work description, and their respective tendered prices reflected. It implies that OLS findings of a category of tasks, such as a kilometer of a specified road section, are not generalizable for, e.g., bridges or buildings.

9. Practical Implications

Providing a construction model with low inflation in tender-price output has several practical implications, particularly in the areas of cost estimation, project management, and stakeholder confidence. Key practical benefits include:

1. Improved Cost Predictability: A model that reduces inflation in tender prices enables more accurate budgeting, helping stakeholders plan projects with a higher degree of financial certainty. This reduces the risk of cost overruns and allows for better resource allocation. The model developed through this study offers a tool that significantly improves the predictability of tender prices, allowing government agencies and construction firms to plan more effectively and allocate resources with greater confidence. By integrating both economic and socio-political factors, the model helps project managers and policymakers forecast tender price inflation more accurately and develop risk mitigation strategies.
2. Enhanced Stakeholder Confidence: With predictable tender prices, clients, contractors, and financiers are more likely to trust the bidding process and the viability of the project. This fosters a more stable environment for collaboration and investment.
3. Competitive Bidding: Low inflation in tender prices ensures that bids are more competitive and reflect realistic project costs, minimizing the chances of underbidding (which could lead to project failure) or overbidding (which could reduce a company's chances of securing a project).
4. Efficient Resource Allocation: Accurate cost models allow for better planning and allocation of resources such as labor, materials, and equipment. This helps in avoiding resource wastage or shortages during the project lifecycle.
5. Risk Mitigation: A model that minimizes cost deviations also reduces the potential financial risk for both the contractor and the client. With fewer price fluctuations, projects can proceed with greater assurance of staying within budget, thereby minimizing the need for contract renegotiations or amendments.
6. Enhanced Tender Price Management: For practitioners in the public procurement and construction sectors, the model provides a comprehensive framework for managing tender price variability, reducing the risk of cost overruns and ensuring that project budgets are more reliable. The application of OLS regression alongside qualitative socio-political insights allows practitioners to account for market volatility, enabling better budget management.
7. Policy Formulation and Governance: Government agencies can use the findings to reform tendering processes by incorporating the identified socio-political factors. The insights gained from this study suggest that more transparent and stable governance practices can reduce tender price volatility, making infrastructure development more sustainable and cost-effective.

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Appendix

Table 8: Tender management strategies

Sector group	Code	Descriptions based on the interviewee's quote	Quantitative Likert-scale statements	Model Fitting Criteria (-2 Log Likelihood of Reduced Model)	Likelihood Ratio Tests (Chi-Square)	Mean	Sig.	Log-likelihood score ranking	Selected Strategy (significant at p<0.05)
Theme 1: What strategies can the government deploy to address tender price inflation?									
Government strategy	GD10	Adapt and change behaviour following prevailing circumstances.	Adopting innovative system	99.466	5.847	3.96	*0.054	1	GD10
	GD4	Invest in information management to support and implement appropriate estimation models and processes. Apply appropriate industry comparators.	Benchmarking price performance	98.926	5.306	4.09	0.070	2	
	GD7	Employ competitive processes that result in desired outcomes.	Improving procurement methods	96.252	2.633	4.32	0.268	3	
	GD3	Consider capacity provision through training programs for local contractors and adopting lean concepts and principles.	Ensuring Continuous capability and capacity enhancement	94.809	1.190	4.22	0.552	4	
Theme 2: What strategies can the contractor deploy to address tender price inflation?									
Contractor strategy	CD1	Develop expertise to perform construction project-related tasks efficiently and costly.	Improving technical ability	107.294	13.675	4.17	*0.001	1	CD1 CD5
	CD5	Develop a competitive advantage through a collection of resources and possessions. Utilize the company's existing internal resources to create strategies and develop the potential for creating a competitive advantage.	Developing resource capabilities	104.591	10.972	4.08	*0.004	2	
	CD7	Develop an understanding of the series of steps and activities involved in procurement.	Developing knowledge of procurement processes	98.147	4.528	4.28	0.104	3	
	CD3	Endeavour to keep expenses low to generate efficient profit margins without worsening the clients' financial or economic results.	Managing profit margin estimations	97.523	3.903	4.05	0.142	4	
	CD2	Ensure delivery of complex projects on time by developing desired capacity and ability to perform—endeavour to employ competent and qualified personnel.	Improving the qualification and competence of the contractor	95.639	2.020	4.12	0.364	5	
Theme 3: What strategies can the industry deploy to address tender price inflation?									
Industry strategy	ID9	Develop strategies for positive stakeholder participation and ensure the timely availability of resources.	Removing industry uncertainty	101.034	7.415	4.20	*0.025	1	ID9 ID14 ID8
	ID14	Develop frameworks that sustain high economic growth levels. Identify and address factors leading to the sector's prolonged state of decline. Improve supply chain management, which builds long-term supplier alliances.	Instilling sector confidence	100.154	6.535	4.13	*0.038	2	
	ID8	Develop deliberate equipment ownership policy and equipment ownership systems.	Encouraging ownership of equipment	99.930	6.311	4.09	*0.043	3	
	ID10	Improve the quality of specification and design.	Managing the number of competitors	97.886	4.267	4.27	0.118	4	
	ID3	Reduce the cost of borrowing. Reconcile interest rates with project cost before tendering.	Mitigating interest rate impacts	95.799	2.179	4.29	0.336	5	
	ID5	Maintain the value of the local currency to guarantee the economic performance of a project and its stakeholders. Maximize utilization of local building materials.	Reducing imports	95.439	1.820	4.14	0.403	6	
	ID1	Understand the justifications for protecting local participation in the industry and developing protectionism policies.	Ensuring the protection of local firms	95.183	1.564	4.19	0.458	7	

	ID12	Disseminate information regarding market fundamentals to guarantee results and reduce the need to recreate the wheel at each tender.	Ensuring market predictability	94.978	1.359	4.16	0.507	8	
	ID17	Develop structured assessment tools to gauge the efficacy of contractors and the workforce. Encourage contractor-management training programs to increase competency and capacity among local contractors.	Providing training	94.668	1.048	4.35	0.592	9	
Theme 4: What strategies can the project deploy to address tender price inflation?									
Project strategy	PD12	Anticipate constraints before tendering the project.	Mitigating risk factors at inception	102.229	8.610	4.34	*0.014	1	PD12 PD10 PD1
	PD10	Ensure implementation of adequate cost controls and management practices.	Mitigating project costs	100.415	6.795	4.31	*0.033	2	
	PD1	Prepare practical and realistic project schedules with a limited timeframe and minimum cost implication.	Upholding project duration specifications	99.923	6.304	4.33	*0.043	3	
	PD5	Encourage good communication regarding the progress of different projects and construction material management. Give special attention to material estimates and handling.	Mitigating the impact of material-price escalations	99.536	5.916	4.20	0.052	4	
	PD4	Develop practical project, scope-managed models. Ensure informed decision-making through project scope.	Clarify the scope of the project from inception	98.405	4.786	4.23	0.091	5	
	PD6	Pursue efficient utilization of equipment. Ensure utilization of advanced and contractor-owned equipment.	Accounting for nature and type of equipment	95.586	1.967	4.06	0.374	6	
	PD13	Anticipate and mitigate the risk of negative stakeholder involvement.	Accounting for the project environment	95.355	1.735	4.17	0.420	7	
	PD11	Develop an efficient overall approach to the project that specifies the tools, equipment, resources, expertise, and implementation techniques.	Accounting for the complexity of the works	95.212	1.593	4.24	0.451	8	
	PD9	Provide possibilities for price adjustment and clearly define necessitating circumstances.	Providing clauses for project variations/price adjustments	94.846	1.227	4.33	0.541	9	
Theme 5: What strategies can the procurement function deploy to address tender price inflation?									
Procurement strategy	MD3	Engage consultants for technical assistance, price assessments, and project evaluation services.	Ensuring the presence & experience of the consultant	102.067	8.448	4.22	*0.015	1	MD3
	MD8	Identify and consolidate requirements and determine the cost-effective timeframe.	Standardizing Procurement timeframe	97.249	3.629	4.25	0.163	2	
	MD7	Develop a project management plan outlining exact courses of action and implementation initiatives.	Establishing project implementation methodology	94.823	1.203	4.26	0.548	3	
	MD4	Develop client project management assessments and project control tools.	Establishing technical & financial controls	94.720	1.101	4.29	0.577	4	
Theme 6: What strategies can the legal function deploy to address tender price inflation?									
Legal strategy	LD2	Provide mathematical descriptions of how changes in the project-item-related factors result in a particular rate.	Legislating rate analysis	99.755	6.136	4.00	*0.047		LD2
	LD3	Provide regulation for establishing a streamlined procurement structure, responsibility, and clear lines of authority.	Legislating procurement controls	97.169	3.550	4.14	0.169		
	LD6	Provide domesticated contract forms that respond to prevailing circumstances.	Domesticating contract type	94.801	1.181	4.14	0.554		
df =147 d. N=147									

*Statistically significant at $p<0.05$
The chi-square statistic is the difference in -2 log-likelihoods between the final and reduced models. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.
Cronbachs Alphas = 0.988