STRUCTURE OF INFRASTRUCTURE BONDS AND OPERATIONAL PERFORMANCE OF ROAD PROJECTS IN NAIROBI METROPOLITAN REGION, KENYA

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D58/CTY/PT/33349/2014

A THESIS SUBMITTED TO THE SCHOOL OF BUSINESS, ECONOMICS AND TOURISM IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN FINANCE OF KENYATTA UNIVERSITY

DECEMBER 2025

DECLARATION

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To my husband David Kibet, our son Kay Kiprotich and daughter Karen Chemtai, my mother Karen Aoko and my siblings the late Kennedy Ochieng',Stephen Okoth and Philemon Odour your perseverance, constant prayers, patience and encouragement have contributed to the success of this thesis.

ACKNOWLEDGEMENTS

My sincere thankfulness to God for the gift of life, for keeping me healthy, and for His kind supply of financial resources that helped me finish my study paper. My sincere gratitude to my university supervisors, Prof. Fredrick W.S. Ndede and Dr. Jennifer G.Njaramba, for their unwavering support, constructive criticism, and valuable suggestions throughout this journey, from the initial concept to final completion of the thesis.

I would like to convey my special appreciation to fellow classmates; Grace, Benedict, Hassan, Enos, Lawrence, Makori, Shadrack, and Victor for their steadfast encouragement and support as I pursued this thesis while managing the demands of my career and family life.

Lastly, I am deeply thankful to my parents, Dr. Pius Adoyo and Mrs. Karen Aoko, for providing me with a strong educational foundation, invaluable exposure, and continuous encouragement, instilling in me the belief that education is the greatest legacy.

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OPERATIONAL DEFINATION OF TERMS

Bond: These are debt instruments used by governments and corporations to secure loans.

Bond Amortization: refers to the regular payments of both principal (face value) and interest over the bond's lifespan (Lee & Johnson, (2020). In the present study, bond amortization was measured in terms of; fixed principal payments, conversion and bullet structure.

Bond Interest Rates: refer to the cost of borrowing funds through bonds, expressed as the percentage of the bond's face value that issuers pay to investors as periodic interest (Yoshino, Azhgaliyeva, & Mishra, 2021). In the present study, bond interest rates were measured in terms of interest rate risk, coupon rates, and term to maturity.

Bond Yield Rates: refer to the overall return an investor expects to earn from holding a bond until its maturity, reflecting both interest income and capital gain or loss (Anderson & Sundaresan, 2020). In the present study, bond yield rates were measured in terms of yield to maturity, bond prices, and coupon payments.

Cost of the Project: refers to the total financial expenditure incurred in the planning, construction and completion of a road infrastructure project (Tarhuni & Mahat, 2024). In the present study, the cost of the project was measured in terms of budgeted cost, actual expenditure, and cost variance.

Coupon Rate: refers to the fixed or variable annual interest payment made by a bond issuer to investors, expressed as a percentage of the bond's face value (Andrić et al. 2024). In the present study, the coupon rate was measured in terms of payment frequency, coupon value, and coupon structure.

Government Policies: refer to the legislative, regulatory, and fiscal measures established by the government to influence economic activities, including infrastructure investment and financing (Cytonn Investments, 2023). In the present study, government policies were measured in terms of tax incentives, regulatory frameworks, and public investment guidelines.

Inflation: Inflation denotes the continuous rise in the overall cost of goods and services within an economy across a given period, leading to a decline in the value of money and its ability to purchase commodities (Vera, 2020). In this study, inflation was assessed using the (CPI), interest rate adjustments, and exchange rate fluctuations.

Infrastructure Bonds: refer to long-term debt instruments issued by the government or public agencies to raise funds for the development of physical infrastructure such as roads, bridges, and utilities (Foster et al., 2023). In the present study, infrastructure bonds were measured in terms of bond tenure, interest rates, and bond yields.

Infrastructure Project Financing: refers to the structured approach of funding large-scale infrastructure developments through various sources, including public funds, private investment, or public–private partnerships (Bosire, 2015). In the present study, infrastructure project financing was measured in terms of funding sources, financing structure, and repayment arrangements.

Infrastructure Projects: refer to large-scale public works aimed at improving essential physical systems such as transportation, energy, and water supply that support economic development and public welfare (World Bank, 2023). In the present study, infrastructure projects were measured in terms of project cost, completion timelines, and performance outcomes.

Nairobi Metropolitan Region: Encompasses the capital city, Nairobi, and its surrounding areas, divided into five sub-regions, including the city itself and neighboring counties specifically Kiambu, Kajiado, Murang'a, and Machakos (Cytonn Investments, 2023).

Performance of Road Infrastructure Projects: refers to the extent to which road construction projects achieve their intended objectives in terms of efficiency, cost-effectiveness, and adherence to planned timelines in the Nairobi Metropolitan Area, Kenya (KPMG, 2023). In the present study, the performance of road infrastructure projects was measured in terms of timely completion of projects and costs of the projects.

Road Infrastructure: Infrastructure for roads includes both the actual physical features of the roads itself as well as everything that goes along with them, such as bus stops, trucking terminals, signs, drainage systems, bridges and tunnels (World Bank, 2022).

ABBREVIATIONS AND ACRONYMS

ADF:	Augmented Dickey-Fuller.
ANOVA:	Analysis of Variance.
ARDL:	Autoregressive Distributive Lag.
CBK:	Central Bank of Kenya.
CBN:	Central Bank of Nigeria**.**
GDP:	Gross Domestic Product.
GNP:	Gross National Product
IDS:	International Debt Statistics.
IMF:	International Monetary Fund.
NMR:	Nairobi Metropolitan Region.
ODA:	Official Development Assistance.
OECD:	Organization for Economic Cooperation and Development.
SSA:	Sub-Saharan Africa.
UN:	United Nations

ABSTRACT

Infrastructure projects in Kenya frequently encounter challenges related to adequate funding and timely completion. The present study seeks to evaluate how the configuration of infrastructure bonds affects the operational efficiency of road development initiatives within the Nairobi Metropolitan Region. In particular, the investigation focused on the extent to which bond interest rates, bond returns, and amortization schedules shape the performance outcomes of road projects in Nairobi, Kenya. Furthermore, the research explored the moderating role of inflation in influencing the relationship between infrastructure bonds and project performance in the region. The inquiry was anchored on three theoretical frameworks: the Efficient Market Hypothesis, the Liquidity Preference Theory, and the Theory of Constraints. A longitudinal research design was adopted to adequately address the study objectives. The target population comprised all 18 road construction undertakings implemented in the Nairobi Metropolitan Region between 2014 and 2022, from which the entire set of projects was examined. A detailed survey of these projects was conducted. Secondary data covering the period 2014–2022 were obtained from multiple institutions, including the Central Bank of Kenya, the National Treasury, the Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works, and the Kenya Urban Roads Authority, using structured data collection templates. The dataset was analyzed through both descriptive and inferential statistical techniques, facilitated by STATA version 14.0. Hypothesized associations were tested using panel regression analysis at a 95% confidence level. The findings revealed that infrastructure bond interest rates, bond returns, and amortization structures exert a significant influence on the performance of road projects within the NMR. The results revealed that higher interest rates and bond yields negatively affect project execution by increasing borrowing costs and constraining available funds, while well-structured amortization schedules positively impact completion by facilitating predictable cash flow and efficient resource allocation. Descriptive analysis showed relative stability in these bond parameters, enhancing investor confidence and reducing financial uncertainty. The findings align with the Liquidity Preference Theory and the Theory of Constraints, highlighting the importance of managing financing costs and systemic bottlenecks to sustain project performance. Based on these results, the study recommends that the National Treasury stabilize bond interest rates and yields through clear issuance schedules and aligned maturities. The Treasury should also enhance amortization management to maintain high, steady repayment rates. The Central Bank of Kenya should continue managing inflation and interest rates to support predictable, affordable financing, while project managers ensure cash flows align with bond repayment schedules to minimize funding gaps and delays.

Keywords: Infrastructure Bonds, Road Projects, Bond Amortization, Economic Uncertainty, Bond Yields, Bond Interest Rates

CHAPTER ONE

INTROCUTION

1.1 Background of the Study

Infrastructure development remains a cornerstone of economic transformation and inclusive growth across the world. Road infrastructure, in particular, facilitates trade, improves accessibility, and enhances regional integration by reducing transportation and logistics costs (Foster et al., 2023; World Bank, 2022; World Bank, 2023). As a public good, governments and local authorities are primarily responsible for financing, constructing, and maintaining road networks to drive productivity and social inclusion (African Development Bank [AfDB], 2021; Foster et al., 2023; World Bank, 2023). The performance of road projects therefore extends beyond engineering outcomes to influence overall national competitiveness, urban mobility, and welfare improvement (AfDB, 2021; Foster et al., 2023; World Bank, 2022).

Globally, the performance of road infrastructure projects has been undermined by cost overruns, schedule delays, and design inefficiencies, which often reduce the anticipated socio-economic benefits (Andrić et al., 2024; Tarhuni & Mahat, 2024; World Bank, 2023). According to Andrić et al. (2024), nearly 60% of public infrastructure projects worldwide experience significant cost and time variances due to weak project planning, poor procurement processes, and inadequate financial management. Similarly, Tarhuni and Mahat (2024) identify funding delays, inflation, and design changes as major causes of cost overruns, while the World Bank (2023) emphasizes the need for effective project governance and innovative financing mechanisms to mitigate such challenges. Consequently, the alignment of financing instruments with project implementation frameworks is essential for achieving timely and cost-effective completion of road projects (Andrić et al., 2024; Foster et al., 2023; Tarhuni & Mahat, 2024).

In Africa, road infrastructure development has gained renewed policy attention due to the continent's large infrastructure deficit and rising urbanization (AfDB, 2021; Foster et al., 2023). The African Development Bank (2021) notes that the infrastructure financing gap in Africa exceeds USD 100 billion annually, prompting governments to adopt innovative financing options such as infrastructure bonds. These bonds allow countries to mobilize domestic savings, reduce external borrowing, and support sustainable project implementation (Afripoli, 2024; Foster et al., 2023). However, the success of infrastructure bonds depends on the structure of the bonds, such as yield rates, maturity periods, and interest structures, and the strength of accompanying project management practices (AfDB, 2021; Afripoli, 2024; Foster et al., 2023).

In Kenya, infrastructure bonds have become a major source of funding for road development under agencies such as the (KeNHA), the (KeRRA), and the (KURA) ([CBK], 2024; Business Daily Africa, 2024; National Treasury, 2023). However, recent reports have revealed persistent challenges including delayed payments to contractors, cost escalation, and slow project completion (Auditor-General, 2023; CBK, 2024). These inefficiencies raise questions about whether the characteristics of infrastructure bonds, such as interest rates, coupon structures, and amortization schedules, affect project performance outcomes (National Treasury, 2023; CBK, 2024; Cytonn Investments, 2023). Addressing these challenges requires an understanding of how bond design influences the timely and cost-efficient completion of projects, particularly in large metropolitan areas.

Within the Nairobi Metropolitan Region (NMR), road infrastructure serves as a critical catalyst for urban productivity, investment attraction, and mobility enhancement. The region contributes approximately 60% of Kenya's GDP and accommodates about 40% of the country's urban population, creating enormous pressure on its transport network

(Kenya National Bureau of Statistics [KNBS], 2023; Cytonn Investments, 2023; Karuga, 2024). According to the Kenya Roads Board (2024), the NMA has over 3,200 km of classified roads, with at least 45% requiring periodic maintenance or reconstruction due to rapid urbanization and increased vehicular traffic. Despite significant investments through infrastructure bonds, several flagship projects such as the JKIA–Westlands Expressway, Eastern Bypass expansion, and Kikuyu–Ruaka link road have faced cost escalations of up to 25% and completion delays averaging 12 to 18 months beyond original timelines (Auditor-General, 2023; Business Daily Africa, 2024; Kenya Roads Board, 2024). These inefficiencies not only inflate public expenditure but also disrupt urban logistics and economic productivity.

The Government of Kenya has issued infrastructure bonds worth KES 716 billion between 2014 and 2023 to finance transport and energy projects, with approximately 28% of these funds directed toward road construction and rehabilitation within the NMA (Central Bank of Kenya [CBK], 2024; National Treasury, 2023; World Bank, 2023). However, inconsistencies in project outcomes raise concerns about whether bond characteristics such as interest rates, yields, and amortization profiles affect project efficiency and sustainability (CBK, 2024; Cytonn Investments, 2023; Karuga, 2024). Financing and ensuring that bond-funded projects achieve timely completion and cost efficiency, which are key indicators of performance in Kenya's infrastructure sector. Accordingly, this study seeks to examine the influence of infrastructure bond characteristics on the performance of road projects in the Nairobi Metropolitan Region, thereby addressing a critical gap in empirical research and policy practice.

1.1.1 Infrastructure Bonds and Operational Performance of Road Infrastructure Projects

Infrastructure projects, particularly road development, rely heavily on well-structured financing mechanisms to ensure timely and cost-effective completion. Among these mechanisms, infrastructure for governments and local authorities seeking to close funding gaps and enhance public infrastructure delivery (World Bank, 2022). The performance of road infrastructure projects, measured through parameters such as cost efficiency, timely completion, and service quality, is influenced by various financial and macroeconomic factors embedded within bond structures (KPMG, 2023). This section discusses four key constructs, bond interest rates, bond yield rates, bond amortization, and economic uncertainty, and how each relates to the performance of road projects.

Bond interest rates determine the cost of borrowing for governments and directly affect the affordability and sustainability of infrastructure projects (OECD, 2022). Higher interest rates increase debt servicing obligations, reducing funds available for project execution and maintenance. Within this construct, three dimensions are significant: interest rate risk, coupon rates, and term to maturity. Interest rate risk captures the uncertainty of future rate fluctuations, which can raise financing costs and disrupt project budgets (AfDB, 2023). Coupon rates, reflecting the periodic interest payments to bondholders, influence the government's long-term financing burden and project cash flow stability (IMF, 2021). The term to maturity also affects performance, as longer maturities provide repayment flexibility but expose projects to prolonged interest volatility (Nguyen et al., 2022). Thus, managing bond interest dynamics is essential for ensuring predictable financing and steady progress in road construction.

Bond yield rates represent the return investors expect from holding a bond, influencing investor appetite and capital inflows toward infrastructure financing (World Bank, 2021). Three dimensions, yield to maturity, bond prices, and coupon payments, collectively shape how governments structure bond instruments to attract investment. A higher yield to maturity indicates greater investor returns but often translates to increased financing costs for governments (OECD, 2023). Bond prices, which fluctuate with market conditions, affect secondary market liquidity and government credibility in future issuances (Kimani & Mutiso, 2021). Meanwhile, coupon payments reflect the periodic cash outflows required to service debt, impacting the fiscal space available for project implementation (Ndung'u & Waweru, 2020). When yields are managed efficiently, governments can attract long-term investors while maintaining cost-effective financing for road infrastructure projects.

Bond amortization refers to how principal and interest are repaid over time. Well-structured amortization schedules, whether fixed principal payments, conversion, or bullet structures, can significantly enhance project performance by aligning repayment obligations with revenue flows (AfDB, 2021). Fixed principal payments ensure predictable debt reduction, improving fiscal discipline and investor confidence. Convertible structures, allowing for partial refinancing or conversion into equity, provide flexibility in managing financial stress (PwC, 2020). Bullet structures, which defer principal repayment until maturity, can support immediate liquidity for project execution but may pose repayment risks later. Therefore, selecting an amortization structure that balances short-term financing needs and long-term repayment capacity is crucial to sustaining road project performance.

Economic uncertainty, particularly inflation, exerts a powerful influence on infrastructure financing and performance. Inflation which in turn raises government borrowing costs (IMF, 2023). In Kenya, inflationary trends averaging between 6% and

8% over recent years have complicated project cost management, leading to delays and budget overruns (Kenya National Bureau of Statistics [KNBS], 2024). Inflation also increases material and labor costs, thereby reducing the purchasing power of allocated funds (World Bank, 2023). Effective macroeconomic stabilization and inflation control are therefore essential for ensuring that road infrastructure projects remain financially viable and are completed within planned timelines and budgets.

The interplay of these financial constructs, interest rates, yield rates, amortization, and economic conditions, determines how effectively infrastructure bonds can support road development. When managed strategically, these factors enable consistent cash flow, reduced fiscal strain, and improved project outcomes (UN-Habitat, 2022). Conversely, volatility in bond markets or macroeconomic instability can result in delayed completion, inflated costs, and compromised quality of road infrastructure (KPMG, 2023). Given the Nairobi Metropolitan Area's growing infrastructure demands, understanding these financial dimensions is key to optimizing bond-based financing frameworks that deliver durable, timely, and cost-efficient road networks.

1.1.2 Operational Performance of Road Projects

The performance of road infrastructure projects is a fundamental determinant of national economic growth and competitiveness. Roads facilitate trade, enhance regional connectivity, and stimulate productivity by reducing transport costs and travel time (World Bank, 2022). Effective project performance ensures that infrastructure investments deliver maximum socio-economic value while minimizing wastage and inefficiencies. Performance in road projects is typically assessed through measurable indicators that reflect efficiency, cost-effectiveness, and quality of delivery (OECD, 2023).

Globally, the performance of road projects is evaluated using a range of methods, including timely completion of projects, cost of the project, kilometers completed, quality of construction, and stakeholder satisfaction (Cheung et al., 2010; Maendo, James, & Kamau, 2018; KPMG, 2023). Timely completion assesses whether projects are delivered within the scheduled duration and is often used to gauge planning effectiveness and contractor efficiency (World Bank, 2021). Cost performance evaluates adherence to budgetary allocations and the ability to control expenditure during implementation (OECD, 2022). Kilometers completed serve as a physical indicator of progress, reflecting the extent of road coverage achieved within a specified period (AfDB, 2023). Other measures, such as quality and user satisfaction, capture the durability and reliability of completed road segments (UN-Habitat, 2022).

In this study, road project performance is operationalized through two key dimensions: timely completion and cost of the project. These metrics were chosen because they are the most widely used and quantifiable indicators of project efficiency and financial discipline (Nguyen et al., 2022). Timely completion reflects the project's ability to adhere to planned schedules, which is essential for reducing economic disruption and ensuring the public quickly benefits from improved transport infrastructure (World Bank, 2023). Cost of the project, on the other hand, represents fiscal prudence and effective resource utilization, both of which are crucial in the context of public sector financing (KPMG, 2023). These two indicators are particularly relevant for Kenya, where delays and cost overruns remain major challenges affecting the delivery of infrastructure projects (KNBS, 2024).

At the global and regional levels, road project performance has often been constrained by poor planning, outdated technologies, and inadequate financing frameworks. In India, approximately 25% of state road projects experience significant delays due to ineffective resource allocation and poor coordination between stakeholders (World Bank, 2021). In South Africa, Vuorinen and Martinsuo (2019) found that local contractors face difficulties meeting timelines and budgets when competing with better-financed foreign firms. Similarly, in Sub-Saharan Africa, an estimated 60% of road projects experience cost escalations exceeding 20% of original budgets due to inflation, procurement inefficiencies, and limited access to affordable credit (AfDB, 2023). These trends underscore the need for sustainable financing mechanisms, such as infrastructure bonds, to enhance predictability and accountability in project delivery.

In Kenya, the performance of road infrastructure remains a critical policy priority. The country’s total road network is estimated at 177,800 kilometers, of which only 16,902 kilometers (9.5%) are paved (Kenya National Bureau of Statistics [KNBS], 2024). Under Vision 2030, approximately 5,681 kilometers have been earmarked for upgrading through restoration, resealing, and tarmacking initiatives (Ministry of Transport, 2023). The Roads 10,000 Programme, launched in 2014 under a public-private partnership framework, sought to accelerate construction but initially faced challenges due to high financing costs (World Bank, 2022). However, the adoption of infrastructure bonds and annuity-based financing has recently improved project financing stability, enabling more predictable completion timelines and better cost control (KIPPRA, 2023).

Overall, the performance of road projects is strongly linked to the effectiveness of their financing mechanisms. Well-structured infrastructure bonds reduce financing uncertainty, ensure timely disbursements, and enhance accountability across all project phases. Therefore, in the context of Kenya’s Nairobi Metropolitan Area, assessing project performance through the dual lenses of timely completion and cost efficiency provides a reliable, evidence-based understanding of how infrastructure bonds influence the successful delivery of road projects.

1.1.3 Economic Uncertainty

In this study, economic uncertainty, proxied by the inflation rate, was conceptualized as a moderating variable influencing the relationship between infrastructure bond characteristics (bond yields, bond interest rates, and amortization profile) and project performance. Economic uncertainty represents a condition in which future macroeconomic conditions become difficult to predict, thereby increasing the risk associated with investment decisions (Brodeur et al., 2021; Ma, Wang, & He, 2022). Inflation, as a key indicator of uncertainty, reflects price volatility, declining purchasing power, and unpredictable cost structures, all of which directly affect the financial environment in which infrastructure projects are implemented (Aizenman, Cheung, & Ito, 2022).

High inflation rates often erode the real value of bond returns, thereby influencing how infrastructure bond yields and interest rates translate into actual project financing outcomes (Baker, Bloom, & Davis, 2020; Altig et al., 2020). When inflation is volatile, which can raise the cost of capital and potentially reduce the funds available for project execution (Petropoulos, Rojas, & Valero, 2022). Similarly, inflationary pressures can distort the expected benefits of stable amortization profiles, leading to unpredictable debt-servicing costs and longer project payback periods (Aastveit, Natvik, & Sola, 2017). Therefore, under conditions of high inflation, the otherwise positive effects of favorable bond terms on project performance may weaken, as investors and project managers become more risk-averse and defer major financial commitments until economic conditions stabilize.

Research evidence indicates that fluctuations in economic stability influence the linkage between financial instruments and organizational performance. According to Liu, Qian, and Wang (2021), uncertainty surrounding economic policies diminished the strength of the positive association between financial sector growth and corporate investment decisions in China. Similarly, Adebayo and Olayemi (2023) showed that inflation, serving as a proxy for uncertainty, moderated the link between fiscal policy interventions and infrastructure project efficiency in Sub-Saharan Africa. Benigno, Eggertsson, and Romei (2021) also reported that macroeconomic uncertainty amplified, thereby affecting the performance of financial assets and investment productivity.

In this study's context, economic uncertainty was expected to moderate variables (infrastructure bond yields, bond interest rates, and amortization profile) and the dependent variable (project performance). Specifically, during periods of high inflation, the beneficial effects of competitive bond yields and manageable interest rates on project performance were anticipated to weaken due to increased borrowing costs, reduced investor confidence, and unpredictable returns. Conversely, during periods of low inflation, stability in the macroeconomic environment was expected to strengthen these relationships by enhancing budget predictability, improving investment planning, and reducing financing risks (Kim, Kumar, Mallick, & Park, 2021; Adebayo & Olayemi, 2023).

Overall, this moderating framework aligns with both theoretical and empirical insights suggesting that inflation-driven uncertainty shapes the risk–return trade-offs in infrastructure financing. By influencing borrowing costs, return expectations, and debt repayment patterns, economic uncertainty fundamentally conditions how infrastructure bond characteristics translate into project performance outcomes.

1.1.4 Nairobi Metropolitan Region

The Nairobi Metropolitan Region (NMR) comprises five counties, that is; Nairobi, Kiambu, Machakos, Kajiado, and Murang'a, and serves as Kenya's principal economic and administrative hub [KNBS], 2023). As the country's industrial and financial nucleus, the region contributes over 45% of Kenya's GDP and houses more than 10 million residents (World Bank, 2023). To sustain rapid urbanization and economic expansion, the government has prioritized road infrastructure development through flagship projects focused on rehabilitation, expansion, and construction of new corridors to improve connectivity and reduce congestion. Between 2014 and 2022, numerous road projects were initiated under government and public–private partnership frameworks, including the Nairobi–Thika Superhighway, Eastern, Southern, Western, and Northern Bypasses (Kenya Roads Board [KRB], 2024). These initiatives aim to modernize transport networks and enhance mobility across the metropolitan area while addressing long-standing infrastructural bottlenecks.

Despite increased access to capital through infrastructure bonds, many projects within the NMR have faced persistent time and cost overruns. Data from the Kenya Roads Board (2024) show that the average completion delay across major metropolitan projects is approximately 27%, while budget overruns average 22%, signaling inefficiencies in cost and schedule performance. These discrepancies highlight how infrastructure bond characteristics, specifically interest rates, yield rates, and amortization profiles, can significantly affect project outcomes. For example, the Nairobi–Thika Superhighway, launched in 2009 and completed in 2012, exceeded its budget by about 15%, reaching Ksh 31 billion against an initial Kssh 27 billion projection (Mbataru, 2018; Republic of Kenya [ROK], 2019). Although it achieved notable operational success by cutting travel time by nearly two-thirds, cost escalations were attributed to exchange rate fluctuations and rising interest charges on syndicated bond financing (World Bank, 2019).

Other major projects are ongoing or nearing completion. The Eastern Bypass, covering 52 kilometers from City Cabanas to Ruiru through Ruai, is being upgraded to bitumen standards (Olivia, 2017). Initially budgeted at Ksh 12 billion, the project's cost has risen to about Ksh 14 billion due to inflation and increased input prices. Between 2018 and 2023, Kenya's inflation averaged 6.9%, while construction material prices rose by over 18%, mainly from imported bitumen and fuel price fluctuations (KNBS, 2024). Similarly, the Northern Bypass, awarded to Sinohydro Limited in 2018, has achieved less than 60% progress as of mid-2024 due to land disputes and funding delays (ROK, 2021). Its cost has escalated by 20%, from Ksh 15 billion to Ksh 18 billion, reflecting increased financing costs linked to fluctuating infrastructure bond yields and delayed disbursements.

Overall, the performance reflects both progress and ongoing challenges. On average, projects have exceeded planned timelines by 25–35% and budgets by 20–30%, primarily driven by economic uncertainty and fluctuations in bond market dynamics. During the 2018–2024 period, infrastructure bond yields averaged 12.5%, while interest rates ranged between 11.7% and 13.9%, depending on tenor (Central Bank of Kenya, 2024). Prolonged amortization profiles and inflationary pressures have increased financial strain on contractors relying on interim payments. Rising inflation has eroded the real value of project budgets, while fluctuating yields and rates have elevated capital costs, slowing project progress (KNBS, 2024). Thus, a well-structured infrastructure bond framework, anchored on predictable yields, moderate interest rates, and flexible amortization terms, is essential to sustain performance and ensure value for public investment in the NMR.

By linking infrastructure bond performance variables, such as bond yields, interest rates, and amortization profiles, and also inflation as a moderator variable to road infrastructure project outcomes in the Nairobi Metropolitan Region, this study underscores how financial mechanisms influence project delivery efficiency. Given the region's centrality to Kenya's economic growth, understanding the relationship between bond-financed projects and their performance outcomes is vital for optimizing infrastructure investment, reducing delays, and improving fiscal accountability.

1.2 Statement of the Problem

Road infrastructure plays a critical role, facilitating trade, investment, and regional integration. Despite this, progress in road development has lagged behind national targets. Out of the 177,800 kilometers of road network, only 16,902 kilometers (9.51%) are paved, while a mere 3.2% has been earmarked for upgrades under Vision 2030 [KNBS], 2024). In the Nairobi Metropolitan Region (NMR), which serves as Kenya's economic hub, persistent project delays and cost overruns remain evident. For instance, the Northern Bypass, initially budgeted at Ksh 15 billion, has escalated to Ksh 18 billion, while the Eastern Bypass rose from Ksh 12 billion to Ksh 14 billion due to inflation and financing inefficiencies. Similarly, average project delays across the region exceed 27%, with most roadworks extending 12–18 months beyond their estimated completion timelines (Kenya Roads Board [KRB], 2024).

These persistent delays and budget variances underscore structural weaknesses in financing mechanisms and project management practices. Of the 61 road projects undertaken within the NMR between 2014 and 2022, only 42% were completed within the original budget, while nearly half exceeded estimated costs by 20–30% (KRB, 2024). Projects such as the Western Bypass (KSh 17 billion) and Nairobi–Thika Superhighway (KSh 31 billion) highlight recurring mismatches between estimated and actual expenditures. Delays in fund disbursement and inflationary pressures have compounded cost escalations, eroding the economic viability of projects. This problem is further intensified by inadequate structuring of infrastructure bonds, whose interest rates, yield rates, and amortization profiles significantly influence project timelines and cash flow stability. Inflation averaged 6.9% between 2018 and 2023 (Central Bank of Kenya [CBK], 2024), driving up input costs and interest charges, factors that directly affect the real value of funds raised through bond financing.

Although Kenya increasingly utilizes infrastructure bonds to bridge the road financing gap, their structural design remains underexplored. Existing studies by Bosire (2015), Gikabia (2015), and Mwaura (2019) examined general financing mechanisms but failed to evaluate how bond features, such as yield to maturity, coupon rates, and amortization schedules, affect road project performance. This study is therefore unique in examining the moderating role of economic uncertainty (proxied by inflation) on the relationship between infrastructure bond characteristics (interest rates, yields, amortization profiles) and road project performance. The aim of this is research, therefore, was to address the gap in existing literature by specifically examining infrastructure bonds and their impact on road project performance in Kenya, with a focus on road construction projects in the Nairobi Metropolitan Region.

1.3 Objectives of the Study

1.3.1 General Objective

This study aimed to investigate the effect of structure of infrastructure bonds on operational performance of road projects in the Nairobi Metropolitan Region in Kenya, as the primary objective.

1.3.2 Specific Objectives

i. To assess the effect of Infrastructure bond yields on operational performance of road projects in Nairobi Metropolitan Region, Kenya.

ii. To find out the effect of Infrastructure bond interest rates on operational performance of road projects in Nairobi Metropolitan Region, Kenya.

iii. To determine the effect of infrastructure bond amortization profile on operational performance of rad projects in Nairobi Metropolitan Region, Kenya.

iv. To establish the moderating effect of inflation rates on the relationship between infrastructure bonds and operational performance of road projects in Nairobi Metropolitan Region, Kenya.

1.4 Study Hypotheses

The study the following null hypotheses:

H_{01}: Infrastructure bond interest rates has no significant effect on operational performance of road projects in Nairobi Metropolitan Region, Kenya

H_{02}: Infrastructure bond yields has no significant effect on operational performance of road projects in Nairobi Metropolitan Region, Kenya.

H_{03}: Infrastructure bond amortization profile has no significant effect on operational performance of road projects in Nairobi Metropolitan Region, Kenya.

H_{04}: Inflation rates do not have a moderating relationship between infrastructure bonds and operational performance of road projects in Nairobi Metropolitan Region, Kenya.

1.5 Significance of the Study

A wide range of stakeholders, including the government and its agencies, policymakers, society, potential investors, researchers and academics did benefit from this research.

For the government and its agencies, this study is valuable because it sheds light on how infrastructure bonds, they issue impact road projects in the country. Understanding this impact is crucial for the government's goal of using infrastructure bonds to fund budget deficits and raise capital for various projects, including infrastructure development. Through this research, the government can assess the performance of its bonds and make informed fiscal policy interventions to ensure the stability of the bond market and align it with its capital development needs and objectives.

This research did be useful for policy makers as well, as it provides insights into how to structure infrastructure bond offerings efficiently and effectively in their prospectuses, potentially leading to higher subscription rates. These findings can inform policy decisions related to infrastructure bond management, stimulating and promoting infrastructural development while managing domestic money supply.

Investors in the bond market did find this research valuable as it can help them predict future trends in bond market , aiding both potential and current investors in making informed decisions about when and where to invest in Kenyan bonds. They did gain a deeper understanding of the factors influencing their investments and performance of the bond market, enabling them make more relevant investment choices.

This study did be useful to academicians since it may be used as a reference for anyone who want to learn more about the connections between the variables in this research or other similar variables. By demonstrating how Modern Portfolio Theory (MPT), the Effect Market Hypothesis Theory, the Liquidity Preference Theory, and the Theory of Constraints may be applied to the research constructs, the paper makes a theoretical contribution. The results can also be used as a guide for academics planning related research topics, assisting them in identifying knowledge gaps that could be the basis for further studies.

1.6 Scope of the Study

The specific goals entailed assessing the impact of infrastructure bond yields, interest rates, and amortization profiles on the performance of road projects in Nairobi Metropolitan Region, Kenya. The study also intended to investigate how economic uncertainty moderating effects on the relationship between infrastructure bonds and the performance of road projects in the Nairobi Metropolitan Region, Kenya.

This research was conducted within the five counties of the Nairobi Metropolitan Region, namely Nairobi, Machakos, Kajiado, Murang'a and Kiambu. The study encompassed all completed and ongoing road construction projects in the Nairobi Metropolitan Region that have taken place between 2014 and 2022. During this period there were a number of road projects were started. This timeframe aligns with the issuance of Kenya's first infrastructure bond, totaling 18.5 billion shillings, in February 2014 and extends to 2023.

1.7 Organization of the Proposed Study

To enhance clarity and coherence, this section outlines the organization of the study and the content covered in each chapter. Chapter One outlines the study's background, offering a theoretical overview of the principal variables and their importance to performance outcomes. It further incorporates the problem statement, research objectives, hypotheses, and guiding questions, together with the rationale and value of the investigation, as well as its scope and constraints, and a brief description of the organization of the subsequent chapters.

Chapter Two, the development of the conceptual and theoretical framework. It critically examines scholarly and empirical studies related to infrastructure bond yields, bond interest rates, bond amortization profiles, and economic uncertainty, showing their connections to road project performance. The chapter further identifies existing knowledge gaps in past research and positions the present study within that context.

Chapter Three elaborates on the methodological framework employed in the investigation. It outlines the chosen research design, the intended population, approaches to sampling, and the process of determining the sample size. In addition, the chapter discusses the formulation of data-gathering tools, the procedures followed during data collection, preliminary testing to establish reliability and validity, as well as the techniques applied for analyzing and presenting the data. Ethical considerations guiding the research process are also discussed.

Chapter Four presents the results and analysis of the study. It includes data cleaning and preparation, descriptive statistics, inferential analyses such as correlation and regression, and hypothesis testing. The findings are interpreted in relation to the study objectives and supported by tables, graphs, and model summaries to illustrate the relationships among variables.

Chapter Five provides a synthesis of the findings, summarizing how they address each research objective. It discusses the implications of the results in light of the reviewed literature and theoretical framework, draws conclusions, and presents practical and policy recommendations. The chapter also highlights areas for further research to guide future studies on infrastructure financing and project performance in Kenya.

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CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This Chapter delves into the existing literature regarding the impact of infrastructure bonds on the performance of road projects. It includes a comprehensive examination of theoretical perspectives, an overview of empirical studies, and a summarization of key findings and identified gaps in the literature, and the development of the conceptual framework.

2.2 Theoretical Review

The research drew upon the principles of the Modern Portfolio Theory (MPT), the Effect Market Hypothesis Theory, the Liquidity Preference Theory, and the Theory of Constraints to guide the study. A multi-theoretical approach was adopted in this study to provide a comprehensive lens through which to examine the complex relationship between infrastructure bond financing and the performance of commercial state parastatals in Kenya. The Modern Portfolio Theory (MPT) explains how excessive public debt can discourage further investment by reducing the perceived returns to private investors, thus highlighting the fiscal prudence required in infrastructure bond issuance (Krugman, 1988; Panizza & Presbitero, 2014).

The Efficient Market Hypothesis (EMH) complements this view by positing that bond markets incorporate all available information in pricing securities, implying that well-functioning capital markets can enhance transparency, investor confidence, and cost-effective financing (Fama, 1970; Hou et al., 2021). Meanwhile, the Liquidity Preference Theory underscores investors' tendency to demand higher yields for long-term securities due to uncertainty, aligning with the need for structured incentives and stable returns in long-term infrastructure bonds (Keynes, 1936; Kim & Shin, 2020).

Finally, the Theory of Constraints provides a managerial perspective by emphasizing that systemic bottlenecks, such as inflation rates, regulatory inefficiencies, fiscal rigidity, or limited institutional capacity, can constrain performance outcomes (Goldratt & Cox, 2004; Dettmer, 2020). Collectively, these theories offer complementary insights into the financial, market, and operational dynamics shaping infrastructure bond utilization and institutional performance.

2.2.1 Modern Portfolio Theory (MPT)

Harry Markowitz first advanced Modern Portfolio Theory (MPT) in 1952 through his influential work "*Portfolio Selection*." Subsequent contributions by Sharpe (1964), Lintner (1965), and Mossin (1966) broadened its scope, establishing a cornerstone of contemporary financial economics. The framework is built on the premise that investors act rationally and prefer to avoid risk, aiming to optimize expected returns relative to a specified level of risk by spreading their investments across diverse assets. MPT posits that portfolio risk can be minimized through proper asset allocation, as the overall risk depends on the covariance among assets rather than individual risks. Its core argument is that diversification leads to an "efficient frontier," where investors can achieve the best possible trade-off between risks and return (Markowitz, 1952; Sharpe, 1964). Thus, MPT provides a quantitative framework for analyzing how asset structure, including bonds, affects overall portfolio performance.

Modern Portfolio Theory has been widely applied to the bond market to evaluate yield-risk dynamics and optimal portfolio allocation. For instance, Agyemang and Abor (2020) used MPT to analyze African sovereign bond markets, demonstrating that diversification across maturities and countries minimizes risk exposure. Similarly, Ochieng (2021) applied MPT to Kenyan government securities, showing that a balanced portfolio of infrastructure and treasury bonds optimizes returns under fluctuating interest rates. In another study, Ngeno (2023) examined East African corporate bonds, revealing that portfolio diversification significantly enhances risk-adjusted returns, especially in economies with volatile inflation rates. These studies underscore the utility of MPT in understanding how bond structuring and risk management influence investment efficiency and financial stability in developing markets.

Despite its strengths, MPT has faced criticism for its unrealistic assumptions of rational investors, normal distribution of returns, and static correlations between assets (Roll, 1977; Fama, 1998). It also underestimates market anomalies and systemic risks, which are especially pronounced in developing economies. Nonetheless, MPT remains relevant when examining infrastructure bonds, as it explains how structural features, such as yield, maturity, and interest rate, affect investor confidence and fund availability. In the current study, MPT helps illustrate how efficiently designed infrastructure bonds attract investment by balancing risk and return, ensuring sufficient liquidity for project continuity. This framework links financial structuring to project performance by demonstrating that optimal bond design minimizes cost overruns and delays in the Nairobi Metropolitan Region's road projects.

2.2.2 Efficient Market Hypothesis Theory

The (EMH), introduced by Fama in 1960, posits that capital markets operate efficiently, with asset prices fully embodying all accessible information. Under this framework, investors cannot consistently outperform the market average since security prices already integrate existing knowledge, thereby limiting opportunities to profit from perceived mispricing of undervalued or overvalued assets. A key aspect of the financial sector's expansion is the expansion of the capital markets, which supports the function of the banking system in promoting economic growth. The capital market, encompassing both the stock and bond markets, lays a critical role in facilitating price discovery, providing liquidity, reducing transaction costs, and transferring risk. By producing and spreading information on firms, these markets also assist in lowering the cost of information, ultimately resulting in efficient markets where prices take into account all information available (Gracia and Liu, 1999: Yartey and Adjasi, 2007). In addition to allocating resources to investors, efficient markets also draw foreign capital into the domestic economy.

In recent times, the credit market has assumed a more prominent role constituting a substantial portion of their financial assets. This trend has developed in part as a result of the bond and equities markets not performing as well as expected (Ngugi et al.,2009) EMH idea, developed by Fama in 1960, describes how a perfect market would behave. In such a market, securities consistently remain in equilibrium, with stock and bond prices fully reflecting all publicly available information and promptly adjusting to new announcements. This implies that securities are accurately and fairly priced, obviating the need for investors to search for mispriced securities.

The Efficient Market Hypothesis (EMH) supports the analysis of how infrastructure bonds affect road project performance by emphasizing the role of transparent pricing and information dissemination. In efficient markets, bond prices reflect all available data, including government credit ratings, fiscal policies, and project risks. This transparency enables investors to make informed decisions, influencing bond uptake and funding availability. If infrastructure bonds are well-structured and priced fairly, they attract capital, ensuring timely project execution. Conversely, mispriced or opaque bonds deter investment. EMH thus highlights the importance of market efficiency in determining how infrastructure bonds translate into successful road project outcomes. This theory offers valuable insights into how efficient markets provide information about infrastructure bond features, including bond yield rates, and how they ultimately impact operational performance of road projects in Kenya.

2.2.3 Liquidity Preference Theory

The theory was introduced by the renowned English economist John Maynard Keynes in the 1930s, posits that investors have a preference for assets with higher liquidity. Liquidity here refers to the simplicity with which assets can be turned into cash. Investors prefer to pay more for assets that are more liquid, while they are likely to pay less for illiquid ones. Because they are less liquid than short-term bonds, long-term government bonds typically have higher interest rates.

In the framework of this study, a critique of the Keynesian model leads to the conclusion that rising government deficits cause interest rates to rise. It is factual that rising interest rates make borrowing money more expensive for the government, which must pay more to use borrowed money obtained through the sale of bonds. It’s important to keep in mind that while the coupon rate denotes a cost to the government, it denotes an investment return to the investor. Consequentially, a rise in interest rates increases the demand for loanable money, which lowers bond prices. Bond yields are then affected by this. Bond yields and prices have an inverse connection in which rising bond prices cause falling yields and vice versa.

It is clear that the Liquidity Preference Theory has importance for this study when taking into account the insights it provides. This study indicates that government bonds with extended maturities are less liquid in both the primary and secondary markets. In contrast, short-term bonds exhibit lower price fluctuations compared to long-term issues, making them the preferred choice for most investors in government securities. Liquidity Preference Theory offers a valuable framework for evaluating how infrastructure bond amortization profiles impact road project performance. Investors prefer short-term, liquid securities due to lower risk and easier convertibility. Long-term bonds, often used in infrastructure financing, are less liquid and require higher interest rates to compensate for uncertainty. This affects the amortization structure, as longer maturities may reduce investor appetite, delay funding, and increase borrowing costs. In Kenya, poorly aligned amortization profiles can lead to under-subscription and stalled projects. The theory underscores the need for designing bond repayment schedules that balance investor preferences with project financing needs for optimal performance. Therefore, the Liquidity Preference Theory was employed to establish a theoretical foundation for the amortization profile of infrastructure bonds and its impact on their subscription and utilization in road projects in Kenya.

2.2.4 Theory of Constraints (TOC)

The Theory of Constraints (TOC) is an approach created to pinpoint and address the major constraint, or limiting factor, impeding the accomplishment of a certain goal. Dr. Eliyahu Goldratt invented this strategy and popularized it in 1984 with his best-selling book "The Goal." Over time, TOC has changed and solidified its place among management best practices.

One notable feature of the Theory of Constraints is its inherent prioritization of improvement activities. The primary focus is always directed toward addressing the current constraints. In environments where urgent improvement is required, TOC provides a highly focused method for achieving rapid enhancements. A crucial implication of this principle is that optimizing non-constraints is unlikely to yield significant benefits; meaningful progress toward the goal, typically increased profit, can only be achieved by improving the constraint. In order to improve the current constraint until it can no longer limit throughput, TOC strives to keep a precise and constant focus on it. Then, the focus switches to the next constraint.

The real power of TOC lies in its ability to create an intense focus on a singular goal (usually profit) and the systematic removal of the primary impediment (the Constraint) hindering the attainment of that goal. In fact, TOC emphasizes on the concept of focus, considering it the essence of the approach. TOC essentially offers a pragmatic means of enhancing system performance by concentrating efforts on strengthening the weakest part of the system until overall system strength improves.

The Theory of Constraints can be effectively applied to the management of road infrastructure projects. Construction projects are complex and time-consuming endeavors, and effective management is essential to achieving satisfactory outcomes. These outcomes include functional satisfaction, aesthetic appeal, on-time completion, budget adherence, value for money, and health and safety compliance. The TOC theory provides valuable theoretical insights in the performance of road projects, particularly by helping identify and address the key constraints and challenges that may hinder successful project execution such as inflation rates.

2.3 Empirical Review

The empirical review section presents findings from previous studies that have examined infrastructure financing and its impact on operational road project performance. It highlights key variables such as bond yields, amortization profiles, and investor behavior, drawing on both local and international research. This section identifies gaps in existing literature, particularly the limited focus on infrastructure bond structures within the Nairobi Metropolitan Region. By analyzing these studies, the review provides a foundation for understanding how infrastructure bonds influence operational outcomes in road development.

2.3.1 Infrastructure bond interest rates on operational performance of road projects

Studies by Smith et al. (2019) and Johnson & Lee (2017) establish a direct link between infrastructure bond interest rates and road project performance. They argue that higher interest rates inflate borrowing costs, reducing available capital and delaying project execution. The World Bank (2018) and Asian Development Bank (2019) reinforce this with quantitative evidence: a 1% interest rate increase leads to a 10% reduction in road coverage and a 5% rise in construction costs, respectively. However, while these studies offer strong macroeconomic correlations, they lack granularity on how bond structures, such as maturity profiles or coupon types, interact with project timelines and investor behavior. This gap suggests a need for more nuanced research that explores the micro-level mechanisms through which interest rates influence infrastructure outcomes, especially in emerging economies like Kenya.

Lam, Chiang, and Chan (2021) provide a regional perspective by examining infrastructure bond uptake in Asia. Their study reveals that despite active financial markets, bond financing remains underutilized due to credit risk concerns, limited market information, and illiquidity. Institutional investors showed more openness to infrastructure bonds, valuing their predictable returns. This contrasts with the findings of Smith et al. (2019), who focus on interest rate impacts without addressing investor sentiment or market structure. Lam et al. emphasize the importance of credit and liquidity enhancement measures, which are largely absent in earlier studies. Their work introduces practical barriers to bond financing, suggesting that interest rates alone do not determine project success. The gap here lies in the lack of integration between financial market dynamics and infrastructure performance metrics, pointing to the need for studies that bridge investor behavior, bond market maturity, and infrastructure delivery outcomes.

Yoshino, Azhgaliyeva, and Mishra (2021) offer an innovative approach by proposing floating-interest infrastructure bonds tied to spillover tax revenues. Unlike fixed-rate bonds, these instruments adjust returns based on regional economic growth triggered by infrastructure investment. This model introduces a dynamic feedback loop between project success and investor returns, contrasting sharply with the static interest rate models in earlier studies. While Smith et al. (2019) and Johnson & Lee (2017) focus on cost implications, Yoshino et al. explore how bond design can incentivize performance. Their emphasis on transparency and accountability also adds a governance dimension missing in other research. However, the model's applicability in less developed financial markets remains uncertain. The gap here is the lack of empirical testing in frontier economies like Kenya, where tax collection and revenue predictability may be limited. Future research should assess the feasibility of such instruments in low-capacity environments.

De Rezende (2017) shifts the focus to monetary policy, analyzing how government bond purchases influence interest rates across different maturities. Using Sweden as a case study, the research identifies two channels, portfolio balance and signaling, that affect term premia and short-term rate expectations. This macro-level insight complements the microeconomic findings of Mugo (2018), who studied Kenya's bond market. While De Rezende emphasizes policy tools to manage interest rates. Together, these studies suggest that interest rate management is multifaceted, involving both central bank actions and broader economic conditions. However, neither study directly links these mechanisms to infrastructure project outcomes. The research gap lies in connecting monetary policy interventions to sector-specific performance, such as road construction. Bridging this gap would help policymakers understand how macroeconomic levers translate into tangible infrastructure results.

Mugo (2018) provides a localized analysis of Kenya's bond market, revealing that interest rates and exchange rates negatively affect bond performance, while inflation has a short-term positive impact. This contrasts with the global findings of Smith et al. (2019) and the policy-focused work of De Rezende (2017). Mugo's use of longitudinal data and econometric modeling adds depth, but the study remains broad, treating the bond market as a whole without isolating infrastructure bonds. This limits its applicability to road project performance. Moreover, while Mugo identifies macroeconomic influences, he does not explore how bond design, such as interest rate type or amortization schedule, affects investor decisions or project execution. The gap here is the absence of sector-specific analysis, particularly in the context of Kenya's infrastructure needs. Future research should disaggregate bond types and link their structural features to road project outcomes.

Across these studies, a consistent theme emerges: infrastructure bond interest rates significantly influence road project performance. However, the research varies in scope, methodology, and regional focus. While global studies offer broad correlations, regional and country-specific analyses reveal practical barriers and policy nuances. Notably, few studies examine the structural design of infrastructure bonds, such as floating rates, amortization profiles, or liquidity features, and their direct impact on project delivery. Additionally, the Kenyan context remains underexplored, especially regarding how bond market maturity and investor behavior shape infrastructure outcomes. This synthesis highlights the need for integrated research that combines financial theory, investor psychology, and infrastructure management. Such work would provide actionable insights for policymakers seeking to optimize bond structures and interest rate policies to enhance road project performance in Nairobi and similar regions.

2.3.2 Infrastructure bond yields on operational performance of road projects

Infrastructure bond yields have played a pivotal role in shaping the financial viability and execution of road projects. Defined by the Asian Development Bank (2019) as the annual return earned by investors holding bonds to maturity, these yields are influenced by interest rates, market prices, and maturity dates. Smith et al. (2020) and Johnson & Lee (2018) demonstrated that higher yields increased borrowing costs, straining budgets and delaying project completion. Observing the bond prices helps explain why rising yields reduce capital accessibility. Conversely, lower yields are improving affordability, enabling smoother financing. While these studies established a foundational link between yields and infrastructure outcomes, they focused primarily on macro-level dynamics. Missing from their analysis is how yield fluctuations are affecting operational metrics, such as contractor performance and procurement timelines, especially in developing regions like Kenya, where road infrastructure remains vital to economic growth.

Exploring the influence of ESG factors, Anderson and Sundaresan (2020) examined how a nation's correlates with sovereign bond yield spreads. Analyzing 20 OECD countries between 1996 and 2012, they found that stronger ESG performance was associated with lower default risk and narrower yield spreads. Their findings added a qualitative dimension to bond yield determinants, suggesting that non-financial indicators are shaping investor confidence. Unlike Smith et al. (2020), who focused on interest rate mechanics, Anderson and Sundaresan emphasized reputational and policy-driven factors. However, their study was limited to sovereign bonds in high-income countries. Applying ESG-linked yield dynamics to infrastructure bonds in frontier economies like Kenya remains an underexplored area. Investigating how ESG reforms are influencing bond market performance and infrastructure financing in such contexts could offer valuable insights for policymakers and investors.

Altman (2019) contributed a novel actuarial approach to evaluating corporate bond performance across credit ratings. By modeling bond mortality similar to life insurance, he revealed that BB-rated bonds outperformed others after four years, despite higher default risks. This challenged assumptions that lower-rated bonds are inherently less viable. While Altman focused on credit quality and long-term returns, his methodology is offering potential for adaptation to infrastructure bonds, which often carry unique risk profiles and repayment structures. Unlike Anderson and Sundaresan's ESG-based analysis, Altman's work is emphasizing quantitative modeling. However, the absence of similar actuarial models for infrastructure bonds presents a research gap. Applying this approach to infrastructure financing could help predict yield behavior and assess risk-adjusted returns for road projects, providing investors and governments with more precise tools for evaluating long-term viability.

Silva, Cortez, and Armada (2023) analyzed European bond fund performance using both conditional and unconditional models. Their findings showed that bond funds generally did not outperform passive strategies, though multi-index models added explanatory power. This suggested that bond yield performance is being influenced more by risk factors than by predetermined information variables. Compared to Altman's credit-based analysis, Silva et al. focused on modeling techniques and market behavior. Their results implied that infrastructure bond yields might be better understood through multi-factor models accounting for macroeconomic volatility and investor sentiment. However, they did not isolate infrastructure bonds or link yield performance to project outcomes. Adapting these models to infrastructure-specific contexts, such as road construction, is offering a promising direction for future research, especially in regions like Kenya where yield predictability directly affects funding timelines and execution quality.

Amiraslani et al. (2023) explored the role of social capital in shaping bond spread behavior, particularly during financial crises. Using environmental and social performance as proxies for trust, they found that firms with strong E&S efforts issued debt with lower spreads and longer maturities during the 2008–2009 crisis. These findings aligned with Anderson and Sundaresan's ESG insights but focused on corporate bonds and crisis periods. The implication is that social trust is buffering yield volatility and improving financing terms. However, governance and bond spreads, suggesting that not all ESG components are influencing yields equally. Applying these insights to infrastructure bonds in non-crisis contexts, especially in Kenya, where public trust and institutional credibility vary, is presenting an opportunity to explore how social capital is stabilizing yields and enhancing road project financing resilience.

Partridge and Medda (2020) and Choi & Kronlund (2018) offered contrasting perspectives on yield behavior. Partridge and Medda found that green municipal bonds in the U.S. outperformed conventional ones, with a "greenium" of 5 basis points in the secondary market. This suggested that environmental branding is lowering yields and attracting investment. Choi & Kronlund, however, cautioned against "reaching for yield," showing that funds chasing high yields often suffered poor risk-adjusted returns. These studies highlighted the tension between yield optimization and risk management. While green bonds are offering favorable terms, aggressive yield pursuit is compromising liquidity and stability. Reconciling these dynamics within infrastructure bond markets in developing countries remains a gap. Kenya's road projects could benefit from green bond strategies, but must avoid excessive yield chasing that undermines project sustainability. Future research should explore balanced yield strategies that align investor incentives with infrastructure performance goals.

2.3.3 Infrastructure bond amortization profile on operational performance of road projects

Empirical studies have consistently highlighted the critical role of amortization profiles in shaping the financial viability and operational success of road infrastructure projects. According to Lee and Johnson (2020) and Smith et al. (2018), longer amortization periods tend to reduce annual repayment obligations, thereby easing financial pressure and allowing for more flexible resource allocation. These findings align with the World Bank's (2018) definition of amortization profiles as structured repayment schedules that influence cash flow and project feasibility. However, while these studies emphasized the theoretical and macroeconomic benefits of extended repayment timelines, they did not explore how amortization interacts with market volatility or investor behavior in emerging economies like Kenya.

In contrast, Hördahl and Shim (2020) examined the impact of bond portfolio flows during the COVID-19 pandemic, revealing how capital outflows from emerging market economies (EMEs) triggered currency depreciation and rising long-term interest rates. Their findings underscored the vulnerability of rigid amortization structures in volatile financial environments. Unlike Lee and Johnson's assumption of stable conditions, Hördahl and Shim emphasized the need for flexible repayment models that can absorb macroeconomic shocks. This divergence highlights a research gap: the lack of empirical testing on how adaptable amortization profiles perform under stress in developing economies, particularly in contexts with limited fiscal buffers and shallow bond markets.

Stavarek (2014) and Johnson and Morales (2017) contributed further insights by analyzing the relationship between bond prices and exchange rates across European and American nations. Both studies agreed that mature financial markets—such as those in the United States and Germany—exhibited stronger correlations and more predictable bond behavior. This indirectly supports the argument that amortization profiles function more effectively in stable environments. However, in newer EU member states, where bond markets were less developed and currencies more volatile, no long-term associations were found. These findings suggest that amortization schedules must be tailored to market maturity. Yet, neither study addressed infrastructure-specific bonds, leaving a gap in understanding how repayment structures should be designed for road projects in frontier markets like Kenya.

Ngabirano (2016) offered a localized perspective by investigating factors influencing corporate bond performance in Kenya. The study found that bond issue size and coupon rate, had a more significant impact than external variables. This contrasts with Hördahl and Shim's emphasis on external shocks, suggesting that in Kenya's context, the design of the bond itself, including its amortization profile, may be more influential than macroeconomic conditions. However, Ngabirano did not isolate amortization as a variable, nor did the study focus on infrastructure bonds. This presents a clear gap in the literature: the need to examine how repayment schedules affect investor uptake, project cash flow, and long-term performance in Kenya's unique financial landscape.

Ngunjiri (2022), the study revealed that structured repayment linked to project revenues positively influenced financial outcomes, especially when moderated by interest rates. These findings support Lee and Johnson's view that amortization profiles enhance feasibility when aligned with project cash flows. Moreover, Ngunjiri found that longer maturities and lower spreads were associated with stronger social capital during financial crises, echoing ESG-linked bond behavior observed in other studies. However, the study did not isolate amortization as a standalone factor, nor did it focus on road infrastructure. This gap underscores the need for targeted research on how amortization structures influence road project financing and investor confidence in Kenya's evolving bond market.

In summary, while there is broad consensus that amortization profiles are central to bond performance and infrastructure viability, the studies diverge in their emphasis—some focusing on macroeconomic stability, others on market maturity or internal structuring. The key insight is that amortization must be context-sensitive: flexible in volatile markets, predictable in mature ones, and strategically aligned with project timelines. The major research gap lies in the absence of infrastructure-specific studies in frontier economies like Kenya, particularly those that empirically test how different amortization schedules affect road project delivery, investor behavior, and long-term financial sustainability.

2.3.4 Economic Uncertainty and operational performance of Infrastructure Bonds

Quddus et al. (2022) carried out an investigation into how investment choices affect corporate financial outcomes, with economic policy uncertainty serving as a moderating factor. Drawing evidence from Pakistan's manufacturing industry, the research sought to explore the extent to which fluctuations in policy uncertainty shape the connection between investment decisions and firms' financial performance. Using panel data from 180 manufacturing firms between 2010 and 2020, the findings showed that economic uncertainty negatively moderated the relationship, implying that high uncertainty weakened the positive impact of investment decisions on profitability and return on equity. The authors concluded that unpredictable economic environments distort capital allocation efficiency and deter optimal investment. However, the study was limited to the manufacturing sector and firm-level financial data, ignoring large-scale infrastructure financing dynamics. The current study bridged this gap by examining how inflation, as a proxy for economic uncertainty, moderates infrastructure bond performance and road project outcomes in Kenya's Nairobi Metropolitan Region.

Yuchao and Geeta (2025) in their study on the moderating effect of economic uncertainty on fiscal subsidies incentivising innovation investment in high-tech manufacturing enterprises investigated how economic uncertainty influences the relationship between fiscal subsidies and innovation investment in Chinese high-tech firms. Using a sample of 250 listed companies from 2015 to 2022, the authors found that while fiscal subsidies promoted innovation, high economic uncertainty weakened this relationship by reducing firms' willingness to undertake long-term risky investments. The study highlighted that policy instability and inflationary pressures disrupt the predictability of returns, leading to delayed innovation activities. However, the study focused solely on innovation-driven sectors, omitting infrastructure development contexts where financial instruments like bonds play critical roles. The current study extended this understanding by exploring how inflation-induced uncertainty moderates the relationship between infrastructure bond structures, such as yield, interest, and amortization profiles, and the performance of large-scale public road projects in Kenya.

Abduzhalilovna (2020) examined how uncertainty and inflation affect project efficiency across industrial and construction investments in Uzbekistan. The objective was to integrate inflation and risk into investment evaluation metrics. Findings revealed that inflationary volatility significantly reduced (NPV) and (IRR), ultimately impairing project viability. The author emphasized the need for adaptive financial structuring that incorporates inflation-indexed cash flow projections. Nevertheless, the study applied macroeconomic simulations rather than empirical project data, limiting contextual applicability to infrastructure financing. The current study filled this gap by empirically analyzing inflation as a moderating factor on the relationship between infrastructure bond variables and road project performance, focusing on how cost escalations and delayed disbursements impact outcomes in the Nairobi Metropolitan Region.

Odidi and Jagong'o (2020) conducted a study, the study aimed to establish how inflation alters the relationship between foreign investment inflows and economic growth using time-series data from 1990 to 2018. Findings indicated that inflation significantly weakened the positive effect of (FDI) and financial market development on Kenya's GDP growth, suggesting that price instability erodes investor confidence and return predictability. However, the analysis was limited to national macroeconomic indicators, without addressing sector-specific investment tools such as infrastructure bonds. The current study addressed this limitation by focusing on inflation's moderating influence within infrastructure financing, particularly its effect on the performance of bond-funded road projects, where cost overruns and repayment volatility are inflation-sensitive.

Vera (2020) in her study sought to determine how inflation affects FDI-led growth in emerging markets. Using annual data from 1980 to 2019 and employing the (ARDL) model, the study found that inflation moderates the growth effects of FDI and financial development negatively by distorting investment returns and weakening capital market efficiency. The study concluded that inflation control is essential for sustainable financial performance. However, it did not examine the infrastructural bond market or project-level financing outcomes. The present study built on Vera's framework by positioning inflation as a moderator that shapes the relationship between infrastructure bond attributes, interest rates, yields, and amortization profiles.

2.4 Summary of the Literature Review and Research Gaps

This section provides a concise summary of reviewed literature and identifies the gaps that currently exist in the available body of research. Table 2.1 offers a condensed representation of these research gaps.

Table 2.1 Summary of the Literature Review and Research Gaps

Author(s)	Objective of the Study	Research Methodology	Key Findings	Research Gaps	How the Current Study Addressed the Gaps
Global Perspective					
Smith et al. (2019)	Examine the effect of infrastructure bond interest rates on road project performance	Quantitative analysis of macro-level bond data	Higher interest rates increase borrowing costs, reduce available capital, and delay project execution	Did not explore bond structures or investor behavior	Analyzed bond structures (interest, yields, amortization) and linked to road completion in Kenya
Johnson & Lee (2017)	Assess impact of interest rates on road infrastructure performance	Quantitative modeling	Higher borrowing costs constrain project execution	Focused on macro-level impacts only	Tested infrastructure-specific bond rates in the Nairobi Metropolitan Region
World Bank (2018)	Assess macroeconomic impact of interest rate changes on infrastructure projects	Econometric modeling	1% interest rate rise reduces road coverage by 10%	Did not analyze bond-specific characteristics or emerging economies	Linked Kenyan bond rates to project execution outcomes
Asian Development Bank (2019)	Quantify effect of interest rate changes on infrastructure costs	Quantitative analysis	1% interest rate rise increases construction costs by 5%	Lacked bond-level and operational data	Examined impact of bond yields and interest rates on road completion
Altman (2019)	Evaluate corporate bond performance by credit rating	Actuarial modeling	BB-rated bonds outperform others after four years	No actuarial models for infrastructure bonds	Adapted actuarial approach to infrastructure bond risk in Kenya
Silva, Cortez & Armada (2023)	Examine European bond fund performance	Conditional & unconditional modeling	Multi-factor models explain yields; funds underperform passive strategies	Did not isolate infrastructure bonds	Applied multi-factor models to analyze infrastructure bond yield behavior

Author(s)	Objective of the Study	Research Methodology	Key Findings	Research Gaps	How the Current Study Addressed the Gaps
Amiraslani et al. (2023)	Role of social capital in shaping bond spread behavior during crises	Panel data analysis	Firms with strong social & environmental performance issued debt with lower spreads	Limited to corporate bonds and crisis periods	Applied social capital and ESG-linked insights to infrastructure bonds in Kenya
Partridge & Medda (2020)	Compare green municipal bonds vs conventional bonds in the U.S.	Secondary market analysis	Green bonds slightly lower yields	Did not examine developing countries or infrastructure context	Explored green bond strategies for road projects in Kenya
Choi & Kronlund (2018)	Assess yield-chasing behavior and risk-adjusted returns	Quantitative analysis	Funds chasing high yields suffered poor returns	Limited to U.S. municipal bonds	Analyzed balanced yield strategies for Kenyan infrastructure bonds
De Rezende (2017)	Effect of government bond purchases on interest rates	Case study, Sweden	Portfolio balance and signaling channels affect term premia & short-term rate expectations	Did not link monetary policy to infrastructure project outcomes	Connected interest rate mechanisms to road project performance
Lee & Johnson (2020)	Effect of amortization profiles on project feasibility	Macro-level theoretical analysis	Longer amortization reduces repayment burden, improves resource allocation	Did not explore investor behavior or market volatility	Tested amortization profiles' effect on cash flow and road project completion
Johnson & Morales (2017)	Bond-exchange rate correlation in Europe & US	Empirical analysis	Mature markets show stronger correlation; less developed markets weaker	No infrastructure bond focus	Applied amortization analysis to Kenya's frontier markets
Stavarek (2014)	Bond price & exchange rate relationship	Quantitative analysis	Stable markets yield predictable bond behavior	Did not examine infrastructure bonds	Linked amortization and market stability to Kenyan road project performance
Smith et al. (2018)	Assess amortization period impact on project feasibility	Quantitative analysis	Longer amortization improves financial flexibility	Lacked empirical testing under volatile markets	Assessed amortization under economic uncertainty for Kenyan road projects

Author(s)	Objective of the Study	Research Methodology	Key Findings	Research Gaps	How the Current Study Addressed the Gaps
Lam, Chiang & Chan (2021)	Examine uptake of infrastructure bonds in Asia	Quantitative & survey-based	Bond financing underutilized due to credit risk, limited info, illiquidity; institutional investors value predictable returns	Lacked integration of market dynamics with project performance	Integrated investor behavior and market maturity effects on road projects in Kenya
Anderson & Sundaresan (2020)	ESG performance and sovereign bond yields	Panel analysis (20 OECD countries)	Strong ESG reduces default risk and narrows yield spreads	Limited to high-income sovereign bonds	Applied ESG-linked insights to infrastructure bonds in frontier economies
Yuchao & Geeta (2025)	Economic uncertainty moderating fiscal subsidies for innovation	Panel data (250 Chinese firms)	High uncertainty reduces willingness for risky long-term investments	Focused on innovation, not infrastructure	Studied inflation's moderating effect on bond-financed road projects
Quddus et al. (2022)	Economic policy uncertainty moderating investment decisions	Panel data (180 manufacturing firms, Pakistan)	Uncertainty weakens positive effect of investment on performance	Limited to manufacturing sector; ignored infrastructure	Analyzed inflation as a proxy for uncertainty moderating infrastructure bond performance
Regional Perspective (Africa)					
Abduzhalilovna (2020)	Inflation & uncertainty impact on investment projects	Macroeconomic simulations	Inflation reduces NPV/IRR; adaptive structuring needed	Lacked empirical infrastructure data	Empirically tested inflation moderation on infrastructure bond performance
Yoshino, Azhgaliyeva & Mishra (2021)	Propose floating-interest infrastructure bonds tied to tax revenues	Conceptual modeling	Floating bonds create dynamic link between project success and investor returns	Lacked empirical testing in developing markets	Assessed applicability of floating-yield bonds for Kenyan road projects

Author(s)	Objective of the Study	Research Methodology	Key Findings	Research Gaps	How the Current Study Addressed the Gaps
Vera (2020)	Inflation moderating FDI-led growth in emerging markets	ARDL modeling	Inflation distorts returns, reduces financial market efficiency	Did not focus on infrastructure bonds	Positioned inflation as moderator of bond variables affecting road project performance
Hördahl & Shim (2020)	Bond portfolio flows during COVID-19	Event-study analysis	Rigid amortization vulnerable to macro shocks	Not focused on infrastructure bonds	Evaluated flexible amortization under economic stress for road projects
Local Perspective (Kenya)					
Ngabirano (2016)	Corporate bond performance in Kenya	Quantitative analysis	Internal factors more influential than macro factors	Did not isolate amortization or infrastructure bonds	Tested amortization schedules' effect on road project completion
Mugo, M. (2018)	Effect of macroeconomic factors on Kenya's bond market	Longitudinal econometric analysis	Interest rates & exchange rates negatively affect bonds; inflation short-term positive	Did not focus on infrastructure bonds	Disaggregated bond types and linked structural features to road projects
Bosire, L. K. (2015)	Determinants of success of urban infrastructure projects in Kenyan counties	Qualitative case study	PPP structure, financing, and governance influence project success	Did not focus on bond-specific financing	Examined infrastructure bond features and project completion in NMR
Gikabia, R. (2015)	Effect PPP structure, financing, and governance influence project success	Qualitative & descriptive	Bond financing affects expenditure patterns	Limited operational-level data on road projects	Linked bond financing patterns to actual road project completion
Githinji, G. W. (2013)	Effect of bond features and project completion in NMR	Quantitative	Inflation, interest, exchange rates influence bond development	Did not isolate infrastructure bonds	Focused on infrastructure bond rates, yields, and amortization

Author(s)	Objective of the Study	Research Methodology	Key Findings	Research Gaps	How the Current Study Addressed the Gaps
Muchiri, M. S. (2019)	Influence of financing options on performance of public infrastructure projects in Trans Nzoia	Case study & survey	Financing mechanisms affect project execution	Did not separate bond-based financing	Focused specifically on infrastructure bond financing for roads
Ngunjiri, P. M. (2022)	Influence bond features and project completion in NMR	Quantitative	Structured repayment linked to project revenues enhances outcomes	Did not isolate amortization or road projects	Tested amortization schedules' effect on road project cash flow and completion
Ochieng, D. (2021)	Bond market efficiency and investment diversification in Kenya	Quantitative analysis	Inefficiencies affect investor allocation; diversification improves performance	Did not link to infrastructure project execution	Analyzed bond efficiency effects on road project funding and completion
Odidi & Jagong'o (2020)	Inflation moderating FDI & economic growth in Kenya	Time-series analysis	Inflation weakens FDI impact on GDP	Focused on macro indicators; ignored sectoral bonds	Examined inflation's moderating effect on infrastructure bonds and road projects

Source: Research survey, (2023)

2.5 Conceptual Framework

A conceptual framework is a compilation of comprehensive ideas and concepts drawn from relevant research domains, utilized to structure forthcoming discussions, as outlined by Mugenda and Mugenda (2019). Figure 2.1 includes infrastructure bond interest rates, infrastructure bond yield rates, and infrastructure bond amortization profiles, while the dependent variable is the performance of road infrastructure projects.

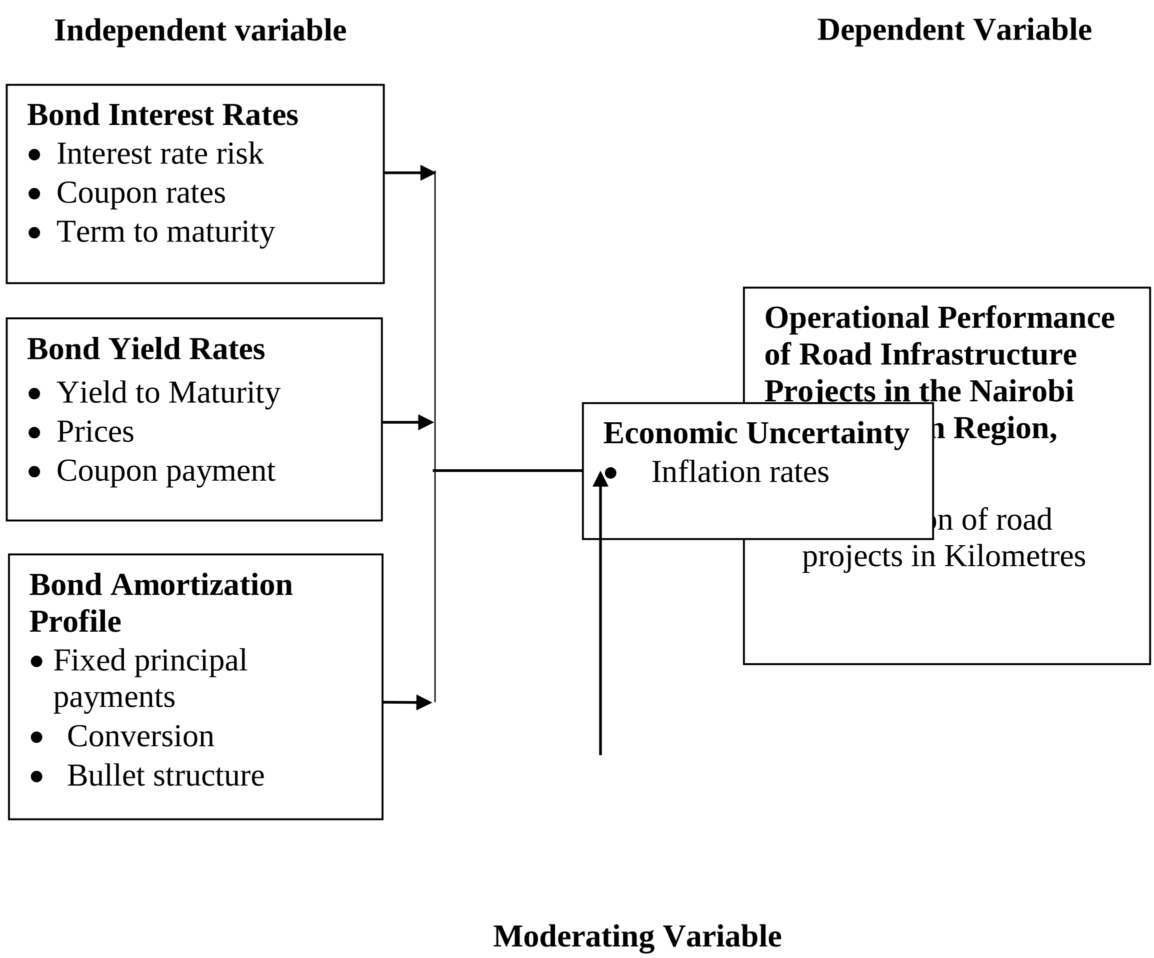

Figure 2.1 Conceptual Framework

Source: Research Survey (2025).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter articulates the methodological framework that guided the derivation of the study's empirical conclusions. It delineates the scope of the investigation, encompassing eighteen road construction projects within the Nairobi Metropolitan Region over an eight-year financial period extending from November 2014 to November 2022. The chapter further explicates the research design, data collection instruments and procedures, analytical and interpretive techniques, modes of data presentation, and the ethical protocols observed throughout the research process.

3.2 Research Philosophy

Research philosophy refers to the framework of assumptions and convictions concerning how knowledge is generated. It shapes the researcher's view of reality (ontology) and the process through which knowledge is obtained (epistemology) (Saunders, Lewis & Thornhill, 2012). In general, four dominant philosophical traditions guide academic investigation: positivism, interpretivism, realism, and pragmatism.

Positivism is based on the notion that reality exists independently of human perception and can be objectively observed, measured, and analyzed. It emphasizes the use of numerical evidence and statistical techniques to identify patterns and causal links. Interpretivism, on the other hand, asserts that reality is socially constructed and is best comprehended through subjective interpretation of meanings and lived experiences. This approach prioritizes qualitative methods and seeks to explain phenomena within their social and cultural contexts. Realism integrates aspects of both positivism and interpretivism, recognizing that although an external reality exists, our comprehension of it is influenced by social, cultural, and situational factors. Pragmatism highlights the practical utility of research, acknowledging that both objective and subjective perspectives may be useful depending on the nature of the research problem.

In this study, a positivist philosophy was adopted, as it aligns with the study's objective of assessing the effect of infrastructure bond structures, such as yields, interest rates, and amortization profiles, on the operational performance of road projects. These variables are inherently quantifiable and lend themselves to statistical analysis. Positivism assumes that phenomena can be observed, measured, and analyzed to reveal empirical regularities and causal relationships. This approach enabled the researcher to collect structured data, test hypotheses, and draw generalizable conclusions based on objective evidence.

In the context of Kenya's infrastructure financing landscape, where decisions are increasingly data-driven and policy-oriented, and a positivist stance provided a rigorous framework for evaluating financial instruments and their impact on project delivery. It also aligned with the study's reliance on secondary data from government reports, bond market indices, and project completion records, as well as primary data collected through structured questionnaires. By maintaining objectivity and minimizing researcher bias, the study ensured that findings were credible, replicable, and relevant to policymakers, investors, and infrastructure planners. Moreover, the adoption of positivism was consistent with previous empirical studies in infrastructure finance and public sector investment, including those by Odhiambo (2020), Ochenge (2018), and Njue (2021), who also employed quantitative methods to explore financial performance and project outcomes. This philosophical alignment reinforced the study's methodological integrity and positioned it within a well-established tradition of evidence-based research.

3.3 Research Design

This study employed a longitudinal research design, selected for its strength in analyzing relationships between variables across time. Longitudinal designs are particularly effective in infrastructure finance research, where the impact of financial instruments, such as infrastructure bonds, on project performance unfolds gradually and is influenced by evolving economic, policy, and market conditions. In this case, the study examined how bond features like yields, interest rates, and amortization profiles affected the operational performance of road projects over a span of eight financial years.

The longitudinal approach enabled the researcher to track changes in bond structures and project outcomes year by year, capturing trends, fluctuations, and lagged effects that a cross-sectional design would miss. This was especially relevant in the Nairobi Metropolitan Region, where road infrastructure development is subject to shifting fiscal priorities, debt servicing pressures, and market dynamics. By employing time series analysis, the study could identify patterns in bond uptake, project completion rates, and financial viability, offering a more nuanced understanding of causality and temporal dependencies.

Moreover, the design supported the formulation and testing of hypotheses regarding the relationship between infrastructure bond characteristics and road project performance. For instance, it allowed the researcher to assess whether rising bond yields in certain years corresponded with slowed project execution, or whether longer amortization schedules improved budget flexibility and completion rates. This hypothesis-driven structure aligned with the positivist research philosophy, emphasizing objectivity, measurability, and statistical rigor.

The longitudinal design also enhanced the study's policy relevance, as it provided insights into how infrastructure financing strategies perform over time, rather than offering a static snapshot. This is crucial for informing future bond structuring, debt management, and infrastructure planning in Kenya and similar frontier economies. Ultimately, the design ensured that the study could capture the dynamic interplay between financial instruments and infrastructure outcomes, offering robust, evidence-based recommendations for stakeholders.

3.4 Model Specification

For this study, the panel regression model was the chosen approach, given its suitability for handling panel data, which aligns with the data structure envisioned for this research. Panel data combines time series and cross-sectional data, where the same cross-sectional unit is measured at various points in time. As the continuous variable of interest in this study is the completion of road infrastructure projects, the regression model was constructed following the recommendation provided by Field (2009).

3.4.1 Direct effect model

The general equation for data analysis, prior to introducing the moderating variable, was as follows:

$$F_{i,t} = \beta_0 + \beta_1 IBI_{i,t} + \beta_2 IBY_{i,t} + \beta_3 IBA_{i,t} + \alpha_i + \lambda_t + \varepsilon_{i,t} \ldots\ldots\ldots\ldots (1)$$

Where: -

F_t= Performance status of road projects over the specified period of time and number of roads as a cross section dimension.

β_0 = Constant

β_1, β_2 & β_3 = parameters to be estimated

IBI = Infrastructure Bond Interest (%)

IBY = Infrastructure Bond Yield (%)

IBA = Infrastructure Bond Amortization (%)

ε =Error Term

3.4.2 Moderating Effect Model

After interacting with the moderating variable, equation (1) becomes;

$$F_{i,t} = \beta_0 + \beta_1, IBI_{i,t} + \beta_2, IBY_{i,t} + \beta_3, IBA_{i,t} + \beta_4, INF_t \& + \beta_5, (IBI_{i,t} \times INF_t) + \beta_6, (IBY_{i,t} \times INF_t) + \beta_7, (IBA_{i,t} \times INF_t) + \alpha_i + \lambda_t + \varepsilon_{i,t} \ldots (2)$$

Where, INF is the moderator variable, inflation rate measured as a continuous variable. INF is interacted with the independent variables and also measured alone in the moderated model. α_i and λ_t are project and year fixed effects respectively, INF_t denotes inflation (economic uncertainty), and the interaction term tests moderation by inflation. The final balanced sample used in estimation comprises (N=18) completed road projects observed over (T=8) annual periods (years), after dropping four projects with unbalanced panels.

Table 3.1 Moderation Decision Rules

Decision	Condition	Interpretation
Moderator present	($P\beta3 < 0.05$) and $\Delta R^2 > 0$	Inflation significantly moderates the relationship between infrastructure bonds and project performance.
Moderator absent	($P\beta3 \geq 0.05$)	Inflation does not significantly alter the relationship.
Strength of moderation	Check magnitude of β_3 and ΔR^2	Larger values implying stronger moderation effect.

Panel data analysis can be approached through three distinct methods, each functioning independently. The pooled panel technique presumes that individuals within the dataset share no unique attributes and that there are no time-invariant effects. The fixed effects model, however, recognizes that every individual possesses specific characteristics that are not random and remain constant over time, implying that intercepts vary across groups or periods. In contrast, the random effects model assumes that individuals have stable traits arising from random variation, unrelated to the explanatory variables. This approach is particularly suitable when the objective is to generalize findings to the entire population rather than limit conclusions to the observed sample.

The choice of model depends on the purpose of the analysis and the extent of endogeneity among the independent variables (Reyna, 2017). The pooled regression framework assumes homogeneity across all financial institutions, an assumption that does not hold in practice. Consequently, this study emphasizes the fixed and random effects models. The fixed effects model accounts for institutional differences by assigning each financial institution its own intercept that remains unchanged over time, whereas the pooled regression model presumes that all coefficients, including intercepts, are identical across institutions. The study used the Hausman test to figure out which model between the random and fixed one is best.

For the purpose of analysis, the moderating effect decision criteria table was used, as shown in Table 3.2.

Table 3.2 Moderating Effect Decision Criteria Table

Criteria	Indicator	Decision Rule	Interpretation
1. Interaction Term Significance	p-value of interaction term (e.g., Bond Feature × Moderator)	If $p < 0.05$ → Significant moderating effect	The moderator significantly alters
2. Change in R^2 (Model Fit)	ΔR^2 between base model and interaction model	If ΔR^2 is substantial and statistically significant	The moderator improves
3. Effect Size of Interaction	Standardized beta coefficient of interaction term	If beta is large (e.g., > 0.1) and significant	The moderator has a meaningful impact on the relationship
4. Direction of Moderation	Positive or negative sign of interaction term	Examine sign to determine whether moderator strengthens or weakens the effect	Helps interpret how the moderator influences the relationship
5. Visualization (Optional)	Interaction plot showing slopes at different levels of moderator	Clear divergence in slopes across moderator levels	Visual confirmation of moderation pattern
6. Theoretical Justification	Support from literature or conceptual framework	Must align with theoretical expectations	Ensures moderation is not spurious or data-driven only

3.5 Variable Definitions and Measurements

The study variables are detailed in Table 3.3, which includes information on each variable, its type, the indicators and quantifiers.

Table 3.3 Operationalization of Variables

Variable	Variable type	Operationalization	Category	Measurement scale
Infrastructure Bond Interest	Independent	Interest rate risk Coupon rates Term to maturity	Ratio	Interest Payment = (Annual Coupon Rate / Face Value) x 100%
Infrastructure Bond Yield	Independent	• Yield to Maturity • Prices • Coupon payment	Ratio	Annual Interest Payment+Face Value-Current Price(Years to Maturity)/Face Value} +Current Price - 2
Infrastructure Bond Amortization	Independent	Fixed principal payments Conversion Bullet structure	Ratio	(AR = Principle paid over a period/ total amount owed)x 100%
Operational Performance of road Infrastructure Projects	Dependent	An evaluation of the extent to which a project fulfills its intended objectives and whether these goals are achieved in line with the prescribed standards of quality. (Kilometres)	Ratio	Project completion rate (%) of planned vs. completed works
Inflation rate	Moderating	Inflation	Ratio	Inflation Rate = (CPI Current – CPI previous) / 100%

Source: Author (2023)

3.6 Target Population of the Study

The population in research denotes the complete set of elements, participants, or objects that exhibit common attributes and are relevant to the investigator, serving as the source of data collection (Bryman & Bell, 2015). In the context of this study, the primary aim is to evaluate how infrastructure bonds influence the effectiveness of road projects within Kenya's Nairobi Metropolitan Region. Therefore, the target population comprised all road construction projects implemented in the Nairobi Metropolitan Region between 2014 and 2022. This period was considered appropriate as it spans a significant timeframe and captures key events that could have influenced infrastructure bond issuance and project performance, such as political and economic fluctuations. The study identified a total of 18 road construction projects funded by the infrastructure bonds and executed within this timeframe (see Appendix III for details).

3.7 Sampling Procedures and Sample Size

Given that the study focuses on projects financed through infrastructure bonds, a purposive sampling technique was employed to ensure inclusion of only those road projects that met this criterion. Out of the identified road construction projects, 18 projects were selected for analysis using the purposive sampling method. The selection was guided by two main considerations: these projects were explicitly financed through infrastructure bonds, and their financial and performance records were more readily accessible. This sampling approach ensured that the selected sample was both information-rich and relevant to the study's objective. The sample size was deemed adequate for generating valid insights, given the relatively small population and the specialized nature of infrastructure bond-financed projects.

3.8 Data Collection Instruments

The researcher utilized secondary data collected using data collection sheets, as outlined in (Appendix II). Employing this data collection sheet assisted the researcher in systematically identifying and acquiring all the necessary data, ensuring that no omissions occur, as advocated by Canals (2017). The study collected yearly data to enable it estimate data trends with more balanced data.

3.8.1 Validity Tests

Validity refers to the extent to which the data collection instruments and analytical procedures accurately capture and represent the constructs under investigation

(Mugenda & Mugenda, 2019). In this study, validity tests were undertaken to ensure that the measures of infrastructure bond features and road project performance truly reflected the underlying concepts as intended in the research framework. Both content validity and construct validity approaches were used to establish the soundness of the instruments and data.

Content validity was established through expert judgment and theoretical alignment. The data collection sheet and variable operationalization were developed based on previous empirical and theoretical studies on infrastructure bonds, public finance, and project performance (e.g., Odhiambo, 2020; Njue, 2021). The researcher submitted the data collection sheet to three experts in infrastructure finance, econometrics, and project management for evaluation. Their feedback was used to refine the indicators, operational definitions, and measurement scales to ensure they comprehensively captured all relevant aspects of infrastructure bond interest, yield, amortization, inflation, and project performance. This process ensured that the data collection instrument accurately represented the study constructs and was free from major omissions or ambiguities.

Construct validity was ensured through the clear operationalization of variables, as presented in Table 3.3. Each variable was linked to measurable indicators grounded in financial and project management theory. For example, the “infrastructure bond yield” variable was defined and measured using the yield-to-maturity model, consistent with standard financial analysis frameworks. Similarly, “project performance” was quantified using completion rates as a percentage of planned versus actual kilometers constructed, ensuring consistency with infrastructural performance benchmarks.

Further, model validity was assessed statistically during data analysis. The study employed panel regression diagnostics to confirm the appropriateness of the specified models, ensuring that the model selection was based on sound statistical reasoning rather than arbitrary choice. In addition, multicollinearity tests were carried out using the (VIF) to confirm that the independent variables were not excessively correlated, which could distort coefficient estimates. Heteroskedasticity and autocorrelation tests were also performed to validate the reliability of regression assumptions, enhancing internal validity.

Collectively, these procedures ensured that the study's findings were not only statistically sound but also conceptually accurate and generalizable to similar infrastructure financing contexts. The rigorous validity testing process enhanced the credibility of the conclusions drawn on the relationship between infrastructure bond structures and the operational performance of road projects in the Nairobi Metropolitan Region.

3.9 Data Collection Methods and Procedure

Secondary data related to infrastructure bonds was sourced from monthly reports published by various institutions, including the (CBK) and the National Treasury. Information regarding the performance of road projects was acquired from the Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works, as well as the (KURA). The data collection process covered a period of nine years spanning from 2014 to 2022, which is considered suitable as it offers a comprehensive dataset for the study. Data collection was facilitated through the use of a collection sheet, and a sample of this sheet can be found in Appendix II for reference.

3.10 Data Analysis and Presentation

The secondary data was collected from published sources was subjected to thorough analysis. This analysis involved the use of both inferential and descriptive statistics, including panel regression and Pearson correlation analysis. Descriptive statistics serve the purpose of highlighting key characteristics within the collected data for the variables of interest, facilitating further data analysis (Creswell, 2014). The descriptive analysis encompassed measures such as the mean, std dev and percentages. To present this information effectively, it was organized into tables and figures.

3.11 Diagnostic Tests

Diagnostics were performed to validate the reliability of the results obtained from the panel regression analysis. Several assumptions were tested, including autocorrelation, normality, linearity, Multicollinearity, Heteroscedasticity, stationarity/unit root, autocorrelation and model specification tests.

3.11.1 Multicollinearity

Multicollinearity refers to a situation in which explanatory variables within a model display strong linear associations with one another, thereby undermining the reliability and clarity of regression estimates. This condition inflates the standard errors of the coefficients, which may cause certain predictors to appear statistically insignificant even when they are not (Thompson et al., 2017; Shrestha, 2020). To evaluate the presence of multicollinearity among the independent variables, the (VIF) was calculated using regression results generated in STATA. Each variable’s VIF score was analyzed to establish the degree of correlation with other predictors. The VIF serves as the primary diagnostic tool for detecting multicollinearity. A value greater than 5 but below 10 signals notable multicollinearity, whereas a value above 10 indicates a severe problem (Thompson et al., 2017). Shrestha (2020) similarly notes that VIF values between 5 and 10 reflect moderate multicollinearity, while those exceeding 10 denote serious multicollinearity. In the current study, all computed VIF values were under the threshold of 10, suggesting that multicollinearity was within acceptable limits (Thompson et al., 2017).

3.11.2 Normality

Normally distributed data exhibits a bell-shaped curve with symmetrical dispersion around the central values (Das & Imon, 2016; Bobbitt, 2022). In contrast, non-normal data often display skewness and kurtosis. To assess normality, skewness and kurtosis were examined. If the skewness and kurtosis values fell within acceptable limits, the data were considered normally distributed and suitable for statistical analysis. Skewness values between -0.5 and 0.5 indicated fairly symmetrical data, while values between 0.5 and 1 (positive skew) or between -1 and -0.5 (negative skew) suggest moderate skewness. Data were strongly skewed if skewness was less than -1 (negative) or greater than 1 (positive). In a normal distribution, kurtosis is exactly 3. If the absolute Z-score for skewness or kurtosis exceeds 1.96, corresponding to an alpha level of 0.05, the null hypothesis that the sample distribution is normal was rejected (Hernandez, 2021; Bobbitt, 2022).

3.11.3 Linearity

Linearity in data is evident when it can be represented by a straight line, signifying a linear relationship between the dependent and independent variables. If this relationship is linear, it allows for effective predictions using panel regression. Linearity was assessed by examining the F-statistic in the ANOVA table of the regression output. The test examines whether the association between the dependent and independent variables follows a linear pattern. Linearity was assessed using the F-statistic derived from the ANOVA table. When the p-value falls below 0.05, the null hypothesis is rejected in favor of the alternative, indicating that the relationship is not linear (Bhandari, 2024; Neal, 2023). Thus, a p-value under 0.05 was considered sufficient evidence to refute the null hypothesis of linearity, indicating a statistically significant linear relationship (Bhandari, 2024; Neal, 2023).

3.11.4 Heteroscedasticity

Heteroscedasticity, as explained by Rosopa, Schaffer, and Schroeder (2013), occurs when the error term exhibits varying variance. This condition occurs when the spread of error terms varies according to the values of the independent variables. Evidence of heteroscedasticity is observed when residuals fail to remain evenly dispersed around the baseline. To identify heteroscedasticity, the Breusch–Pagan test was applied. Within this procedure, the null hypothesis presumes constant variance (homoscedasticity). Rejection of the null indicates that heteroscedasticity exists in the dataset. A significance threshold below 0.05 results in rejecting the null hypothesis (Breusch & Pagan, 1979; Klein et al., 2016). In this study, heteroscedasticity was examined using STATA commands, where the squared residuals were regressed against the independent variables to detect variance inconsistency. The null hypothesis assumed homoscedasticity, and any p-value less than 0.05 was taken as grounds to reject it, indicating the presence of heteroscedasticity (Breusch & Pagan, 1979; Klein et al., 2016).

3.11.5 Stationarity Test

The stationarity of the time series variables, such as infrastructure yields, bond values, amortization profiles, and inflation rates, was assessed using unit root tests. In particular, the (ADF) test and the (PP) test were utilized to assess whether the variables exhibited stationarity or required transformation through differencing (Dickey & Fuller, 1979; Phillips & Perron, 1988). Stationarity remains a fundamental prerequisite in time series modeling, since the presence of non-stationary data may generate misleading or spurious regression outcomes (Gujarati & Porter, 2009).

3.11.6 Autocorrelation

Autocorrelation violates the assumption of independent errors and can bias standard errors, leading to unreliable hypothesis testing (Wooldridge, 2016). The Durbin-Watson statistic provided a preliminary check, while the Breusch-Godfrey test offered a more comprehensive assessment, especially in models with lagged dependent variables.

3.11.7 Model Specification Tests

Model specification was evaluated using the Ramsey (RESET). This test helped determine whether the functional form of the model was correctly specified and whether any relevant variables had been omitted (Ramsey, 1969). A significant RESET test result would indicate potential misspecification, prompting a re-examination of the model structure and variable selection.

3.12 Ethical Considerations

Ethical considerations plays a critical role in ensuring the integrity and credibility of the study. One key ethical concern is ensuring the confidentiality and privacy of organizations whose data was being used. To mitigate this concern, the researcher prioritized using anonymised and aggregated data whenever it was possible, the privacy of organizations involved in infrastructure projects was preserved. Additionally, researchers adhered to copyright and intellectual property laws while accessing and using secondary data sources. Obtaining proper permissions and citations for copyrighted materials was essential to avoid plagiarism and legal issues. Proper documentation of data sources and permissions mitigated the ethical concern related to intellectual property rights. The researcher also endeavoured to obtain the necessary research license from the (NACOSTI) prior to embarking on the study.

Another ethical consideration in collecting data for this research topic is the accuracy and reliability of the data sources. To mitigate this concern, the researcher critically evaluated the credibility and reputation of the sources from which they were obtaining secondary data. It was essential to use data from reputable institutions, government agencies, or scholarly publications to ensure the reliability and the accuracy of the information being used in the study. Cross-referencing data from multiple reliable sources also enhanced the validity of the findings and reduced the risk of relying on potentially biased or inaccurate information. Additionally, transparent reporting of the methods used to identify, select, and evaluate secondary data sources was crucial. By providing clear documentation of the data collection process, the researcher enhanced transparency and accountability of the work, addressing ethical concerns related to data accuracy and reliability in the context of infrastructure bonds and road projects.

CHAPTER FOUR

EMPIRICAL RESULTS, INTERPRETATION AND DISCUSSIONS

4.1 Introduction

This chapter contains the findings and discussions of the study and test of the hypothesis depicted in the study. The study aimed to establish the effect of bonds on the performance of road projects in Nairobi Metropolitan Region, Kenya. The specific goal of the study were to evaluate the effects of; infrastructure bond interest rates, infrastructure bond yields, and infrastructure bond amortization profile. It also aimed to establish the moderating effects of economic uncertainty on the relationship between infrastructure bonds and performance of road projects. The chapter is organized in terms of descriptive statistical analysis, model diagnostic tests, inferential statistical analysis, and hypothesis testing.

4.2 Descriptive Statistics Analysis

The study initially aimed to identify the characteristics of data patterns, including the computation of mean values, std dev s, standard errors, and the minimum and maximum observations for each variable. This section further introduces the correlation matrix, which was employed to detect strong interrelationships among variables—a common occurrence in time series datasets that signals the existence of multicollinearity. Additionally, the analysis considered the potential presence of heteroscedasticity and emphasized the necessity of maintaining dimensional consistency across the variables, therefore, the values were first transformed to their natural logarithms. The following notations were used to represent the respective variables after the transformation. Kilometres Completed (KC) was used for performance of road projects in Nairobi Metropolitan Region, Kenya, BIR was used for bond interest rates, BY was used for bond yields, BAP was used for bond amortizing profile, and Economic uncertainty through Inflation rate, IFR. Table 4.1 gives a summary.

Table 4.1 Descriptive Statistics Results

	Bond Yields (%)	Bond Interest Rates (%)	Bond Amortization Profile (%)	Inflation Rate (%)	Kilometres Completed
Mean	12.1129	11.95	43.22	6.32	182.4378
Max	13.938	13.65	50.00	8.01	250.8
Min	10.2	10.65	20.00	4.69	100.5
Std.Dev.	0.972522	0.889835	0.105805	1.04	55.25772
Skew	-0.1526	0.06547	-0.2978	0.04263	-0.1146
Kurt	-2.9092	-2.9244	-2.5522	2.90533	-2.8942
Sum	254.371	107.55	907.52	56.87	1641.94

Source: Field Data (2024)

Table 4.1 showed that performance of road projects measured by the completion in kilometers of the roads in the Nairobi Metropolitan Region had a mean of 182.4378 kilometers per year for the 8 years that the study focused on, that is, 2014 – 2022. The total kilometers of roads (of all classes) built in the area during the specified period was 1641.94 km. The std dev for the KC was 55.25772 km while the skewness was -0.28862 and kurtosis of -1.60419 for the same period. This implied that the position of the infrastructure bonds was positive and were being well absorbed into the road's projects. As such, it was likely that the subscription of the infrastructure bonds had a strong relationship with the performance of the road's projects.

The maximum value of KC was observed at 250.8 km while the minimum value was observed at 100.5 km, which meant that the subscription to the infrastructure bonds was stable over the period. It also suggests that there were times within the period where the revenues raised by the bonds were only able to suffice for fewer kilometres of roads below the mean while in other times when there was better subscription it was possible to build more kilometres of roads.

The mean value for infrastructure bond yields was 12.11292 % for the period 2014 to 2022, which was positive indicating that the infrastructure bond yields contribute highly to the performance of the road projects. The std dev for infrastructure bond yields was 0.972522, which is less than unity meaning that there was a relatively small variability in the bond yields over the years. The relatively stable bond yield rates has the likely effect of stabilizing the bond prices. Many infrastructure investments have been adversely affected by the sharp and historic increase in interest rates and long-term government bond yields (Chandra et al., 2023). Broad infrastructure investment trusts such as International Public Partnerships and HICL have seen share price falls of between 15% and 20% year to date, an uncomfortable ride for a traditionally defensive sector (Megananda, Endri, Oemar & Husna, 2021).

The mean value for infrastructure bond interest rates stood at 11.95% with a maximum of 13.65% and a minimum of 10.65% for the same period. The positive value > 10% was indicative of the stability of the interest rates over time which could have been a motivating factor for investors. Over 10% returns per year is high for many markets and many investors would consider such returns over many other investment portfolios. The results support those of Obur (2016) rate fluctuations and performance of Nairobi securities exchange markets and found out that interest have a have a positive and significant impact on the relationship between foreign exchange rates fluctuation and the performance.

The mean infrastructure bond amortization profile stood at 43.22% with a maximum of 50% and a minimum of 20%, and with a std dev of 0.820304 for the same period. The positive value of the amortization rate which throughout the period considered was above 50% was indicative of positive bond amortization rates over time which likely attractive to investors and also helped keep the interest rates low and kept the financial markets stable. Research consistently highlights the significant influence of the amortization profile of infrastructure bonds on the performance of road projects (Lee & Johnson, 2020; Smith et al., 2018).

Numerous scholarly investigations have illuminated the intricate connection between bond amortization schedules and the financial viability of such projects. A longer amortization period, typically associated with lower annual repayment amounts, can help alleviate immediate financial burdens on road projects. This, in turn, provides greater flexibility in budget allocation and resource management (Lee & Johnson, 2020). Conversely, a compressed amortization schedule with higher annual repayments may strain project cash flows, potentially affecting the projects ability to meet its financial obligations and execute essential components (Smith et al., 2018). This linkage underscores the pivotal role of bond amortization profiles in shaping the financial sustainability and success of road projects, as they significantly influence the flow of funds over the project's lifespan.

The inflation rate had a mean of 6.32% and a std dev of 1.04% with a maximum of 8.01% and a minimum of 4.69%. This indicates that interest rates had been stable over the period which was indicative of a stable macro-economic environment that is good for investors. Inflation and changing interest rates are the two twin factors that affects bond price. A rise in either the inflation rate or interest rate tend to cause a drop in the bond prices. Interest rates and inflation rates.

4.3 Diagnostic Tests

For regression analysis it is necessary to carry out diagnostic tests. The test carried out include: Test of Normality and Test for Stationarity -Unit Root Test.

4.3.1Test of Normality

In estimating a panel regression model with multiple variables, ensuring that the dataset follows a normal distribution is a key prerequisite. To evaluate normality, this study applied skewness and kurtosis measures. Skewness and kurtosis reflect the asymmetry present in a distribution (Baker, 2019) and can be classified as either positive or negative. A positively skewed distribution occurs when the right-hand tail is more extended than the left, implying that most values lie to the left of the mean while extreme observations cluster on the right. Conversely, a negatively skewed distribution—also referred to as left-skewed—arises when the left tail is longer, indicating that the bulk of values are concentrated on the right side of the mean. Kurtosis, on the other hand, quantifies the degree of "tailedness" in a distribution, highlighting the presence of extreme values relative to a normal curve. Tailedness is how frequently outliers occur. Excess kurtosis in the Tailedness of a distribution relative to a normal distribution. Values approaching zero suggest that the distribution closely resembles a normal curve, whereas negative values imply that the data are flatter compared to the standard normal distribution. Conversely, positive kurtosis values indicate distributions that are more sharply peaked than the normal. As noted by Flammer (2016), skewness and kurtosis values ranging between –2 and +2 are considered acceptable for statistical evaluation. The descriptive results of the normality assessments conducted in this study are presented in Table 4.2.

Table 4.2 Test of Normality

Statistic	Bond Yield	Bond Interest	Bond Amortization	Inflation	Kilometres Completed
Mean	24.90002	2.47797	24.31487	1.862919	5.154556
Skew	-0.1526	0.06547	-0.2978	0.04263	-0.1146
Kurt	-2.9092	-2.9244	-2.5522	2.90533	-2.8942
Jarque-Bera	4.9913	4.9987	4.0066	4.9281	4.9169
Prob.	0.082	0.082	0.135	0.085	0.086
Sum	5.538794	3.104664	2.205543	16.76627	46.391
Sum.Sq.Dev.	89.10887	8.00122	79.76098	6.234586	16.90499

Source: Field Data (2024)

Table 4.2 shows that the results of the normality test indicated that the skewness values ranged between −0.2978 and 0.06547, and kurtosis values between −2.9244 and 2.90533. These values fall within the acceptable range of −1 to +1 for skewness and −3 to +3 for kurtosis, implying near-symmetrical and moderately peaked distributions. The Jarque–Bera statistics for all variables (JB = 4.006–4.999; $p > 0.05$) further confirm that the data were approximately normally distributed. Hence, the normality assumption for regression analysis was satisfied. Therefore, from the results, it is evident that all the variables were normally distributed and further interpretation of the data was not expected to be affected by lack of normality. Consequently, the study carried out the Unit Root Test for all variables.

4.3.2 Test for Stationarity -Unit Root Test

It can be said that spurious regression is a common problem that arises during the process of constructing suitable regression models. Hence, the study checked for stationarity in an effort to determine whether the models had spurious regression. In other words, a stationarity test is conducted with the view of determining whether the value of a variable is changing or is constant over time. What this means is that fluctuation within a time frame does not act as an element that results to change in the value of a variable. Thus, with a view of ascertaining the stationarity in the series and to ensure that the observed regression was not the result of spurious regression, the study conducted a unit root test. In a similar manner, Toliver (2020) states that the best way to articulate the idea is in simple terms, where a variable in an analysis must have no unit root which is symbolized in literature by 1(0) and a way of saying that the series is integrated at order 0. A non-stationary variable can possess one or more than one unit root; I(d) define the fact that the series is integrated of order d where d represent the number of the unit root and therefore the times the variable has to be differenced before achieving stationarity.

4.3.2.1 Unit Root Tests at Intercept and Level

The study also conducted the unit root at Intercept and Level on all the variables under consideration. Table 4.4 refers the Unit Root Test at Intercept and Level.

Table 4.4 Panel Unit Root Tests-based on Levin, Lin & Chu t* statistic

Variable	Statistic	Prob.**	Cross Sections	Obs
Road Kilometers Completed	-8.93338	0.0000	14	112
Bond Yields	-3.41253	0.0005	14	112
Bond Interest Rates	-3.72116	0.0004	14	112
Bond Amortization Profile	-5.66116	0.0000	14	112
Inflation Rate	-10.5718	0.0000	14	112

Panel unit root test: Summary Sample: 2014 - 2022

Table 4.4. Shows that Road Kilometers Completed as a stationary at intercept and level because according to the observation made that the Levin, Lin & Chu t* statistic has a p-value of 0. 0000 ≤ 0. 05. Therefore, we fail to support the null hypothesis that RKC is integrated of order 0. At the intercept level of the series Bond Yields was stationary due to the fact that the Levin, Lin & Chu t * statistic p-value was 0. 0005 ≤ 0. 05. Therefore, we are forced to reject the null hypothesized is false, and conclude that BY has no unit root.

The interest rate variable was found to be stationary at the intercept and level I(0), as evidenced by the Levin, Lin & Chu t* statistic, which produced a p-value of 0.0004 ≤ 0.05. Consequently, the null hypothesis that the (BIR) contains a unit root was rejected. Similarly, the bond amortization profile demonstrated stationarity at the intercept and level I(0), supported by the Levin, Lin & Chu t* statistic yielding a p-value of 0.0004 ≤ 0.05. This outcome provides sufficient grounds to reject the null hypothesis that the bond amortization profile (BAP) is characterized by a unit root.

Table 4.4 shows that Inflation Rate was at intercept and level I (0) being a stationary because Levin, Lin & Chu t* statistic actually had a p-value of 0. 0004 ≤ 0. 05. As a result, our verdict is to reject the null hypothesis that IR is non-stationary and possesses a unit root.

4.3.2.2 Multicollinearity and Autocorrelation Tests

To guarantee the reliability of the regression model, the study evaluated the presence of multicollinearity among the explanatory variables and examined autocorrelation within the residuals. Multicollinearity was analyzed through the (VIF) alongside Tolerance statistics, whereas autocorrelation was investigated using the Durbin–Watson measure and the Breusch–Godfrey Serial Correlation LM procedure. The results are summarized in Table 4.5.

Table 4.5 Multicollinearity and Autocorrelation Tests

Variable	Tolerance	VIF	Durbin–Watson	Breusch–Godfrey LM Test (p-value)
Bond Yield	0.29	3.4483	2.507	0.267
Bond Interest Rates	0.625	1.599		
Bond Amortization Rate	0.381	2.6247		
Inflation Rate	0.811	1.233		
Decision / Interpretation			No significant autocorrelation	Fail to reject H_0: residuals independent

Source: Field Data (2024)

The study assessed multicollinearity among the independent variables using (VIF) and Tolerance values. According to Field (2013), a VIF greater than 10 or a Tolerance below 0.1 indicates severe multicollinearity. As presented in Table 4.5, the VIF values ranged from 1.2330 to 3.4483, while Tolerance values ranged from 0.290 to 0.811. These values fall well within acceptable thresholds, suggesting that multicollinearity was not a concern in the regression model. Specifically, Bond Yield (VIF = 3.4483; Tolerance = 0.290) exhibited the highest level of shared variance with other predictors, whereas Inflation Rate (VIF = 1.2330; Tolerance = 0.811) showed the least. This confirms that each independent variable and the moderating variable contributed unique explanatory power, making them suitable for inclusion in the model.

Autocorrelation was evaluated using both the Durbin–Watson statistic and the Breusch–Godfrey Serial Correlation LM test to ensure a comprehensive assessment of residual independence. The Durbin–Watson statistic yielded a value of 2.507, slightly above the neutral value of 2, indicating weak negative autocorrelation that is not statistically significant. In addition, the Breusch–Godfrey LM test yielded a p-value of 0.267, which is greater than the 0.05 level of significance. As a result, the null hypothesis asserting the absence of serial correlation was retained, confirming that the residuals are mutually independent. The overall findings from these diagnostic checks indicate that the regression model adheres to the fundamental assumptions underlying classical linear regression. The absence of serious multicollinearity ensures that coefficient estimates are stable and interpretable, while the lack of significant autocorrelation guarantees the efficiency of the estimates and validity of hypothesis tests (t-tests and F-tests). Overall, these results affirm that the model was robust, reliable, and appropriate for analyzing the relationship between infrastructure bond characteristics and road project performance in the Nairobi Metropolitan Region.

4.3.2.3 Heteroscedasticity Tests

The Breusch–Pagan test was performed.

Table 4.6 Heteroscedasticity Tests

Test Statistic	Degrees of Freedom (df)	Critical Value ($\chi^2_{0.05}$)	Decision	Conclusion
6.498	3	7.82	Fail to reject H_0	No evidence of heteroscedasticity

Source: Field Data (2024)

As presented in Table 4.6, the calculated Chi-square statistic was 6.498 with three degrees of freedom, compared against the critical Chi-square threshold of 7.82 at the 5% level of significance. Because the obtained value (6.498) is lower than the critical benchmark (7.82), the analysis did not reject the null hypothesis (H_0) of homoscedasticity. This finding indicates that the residuals maintain constant variance, thereby showing no evidence of heteroscedasticity within the regression framework. Consequently, the Ordinary Least Squares (OLS) estimators remain efficient and unbiased, and the model satisfies one of the key classical linear regression assumptions. Therefore, the reported coefficients and significance tests can be considered statistically valid and reliable for inferential interpretation.

4.4 Inferential Analysis

The study further conducted inferential statistical analysis with the objective of identifying the associations among the principal variables and evaluating the stated hypotheses. For this purpose, panel data analysis was undertaken using the (OLS) technique over an eight-year span from 2014 to 2022. The analysis sought to determine the influence of infrastructure bonds on the performance of road projects within the Nairobi Metropolitan region of Kenya, while simultaneously examining the mediating effect of economic uncertainty in this relationship. Accordingly, data were gathered annually throughout the study period to guarantee sufficient degrees of freedom for the models estimated. The panel data estimators based on the System GMM were to mitigated the main endogeneity concerns and therefore generate more appropriate inferences even in cases of no availability of instrumental variables and natural experiments external to the model.

4.4.1 Correlation Analysis

There was also need to test for highly correlated variables and determine whether there was multi-collinearity in the model. Therefore, the study deployed data in their transformed natural logarithmic form, in order to tackle the problem of large values as well as eliminating heteroscedasticity and mitigating multicollinearity issues which may lead to serial correlation in the model. The data were next analyzed using correlation analysis to check whether there is any highly correlated variable. The idea was to eliminate the multicollinearity of in the model. Table 4.7 demonstrates correlation coefficients results for the year 2014 to 2022.

Table 4.7 Correlation coefficients results

		Bond Yield	**Bond Interest Rates**	**Bond Amortization Rate**	**Inflation Rate**	**Kilometers Completed**
Bond Yield	Peearson Coorrelation	1				
	Sig(2tailed)					
Bond Interest Rates	Peearson Coorrelation	0.152	1			
	Sig(2ailed)	0.091				
Bond Amortization Rate	Pearson Correlation	0.129	0.440	1		
	Sig. (2-tailed)	0.101	0.236			
Inflation Rate	Pearson Correlation	0.174	-0.175	0.015	1	
	Sig. (2-tailed)	0.065	0.652	0.970		
Kilometers Completed	Pearson Correlation	.889**	0.358	.876**	0.270	1
	Sig. (2-tailed)	0.001	0.010	0.002	0.030	

** Correlation is significant at the 0.01 level (2-tailed).

Source: Field Data (2024)

The results in Table 4.6 present the Pearson correlation coefficients among the study variables. The analysis indicates that Bond Yield exhibited a strong and statistically significant positive correlation with road project completion, with a correlation coefficient of 0.889 (p = 0.001). This suggests that higher infrastructure bond yields were associated with greater kilometers of roads completed in the Nairobi Metropolitan Region (NMR).

Bond Interest Rates showed a weak positive correlation with road completion ($r = 0.358$, $p = 0.010$), indicating a modest relationship between the cost of borrowing and project output. In contrast, Bond Amortization Rate demonstrated a strong and positive correlation with road completion ($r = 0.876$, $p = 0.002$), highlighting that well-structured amortization schedules are closely linked to higher project completion levels.

The Inflation Rate exhibited a weak positive correlation with kilometers completed ($r = 0.270$, $p = 0.030$), suggesting a limited and non-substantial relationship with road project output over the study period.

Overall, the findings indicate that the primary independent variables, Bond Yield, Bond Interest Rates, and Bond Amortization Rate, have meaningful bivariate associations with road project completion. Inflation, as a moderating variable, did not show a strong direct correlation with completion levels. Furthermore, the correlations among the independent variables were not excessively high. These results provide initial evidence that infrastructure bond characteristics play a significant role in influencing road project performance in the NMR.

4.4.2 Model Specification Tests

Panel data models are highly valuable in empirical research because they enhance estimation precision by combining both cross-sectional and time-series dimensions of data (Hoechle, 2007). According to Gujarati (2012), three main approaches are commonly applied in estimating panel data models: the Pooled (OLS) model, the (FE) model, and the (RE) model. Selecting the most appropriate model requires empirical testing to ensure that the assumptions underlying the chosen estimator are valid. To achieve this, the study employed three key specification tests: the Chow Test, the Breusch–Pagan Lagrange Multiplier (LM) Test, and the Hausman Test.

The pooled OLS model serves as a baseline, meaning that all entities share identical intercepts and slope parameters. However, in practice, this assumption rarely holds because unobserved heterogeneity, such as institutional, managerial, or environmental factors, may influence the dependent variable differently across units. To account for these variations, the study first applied the Chow Test to determine whether a fixed effects model provides a statistically superior fit to the pooled model. A significant Chow statistic indicates the presence of individual-specific effects, thus justifying the use of the fixed effects model.

Next, the Breusch–Pagan (LM) Test was conducted to assess whether the random effects model is more suitable than the pooled OLS model. This test evaluates whether there is significant variance across cross-sectional units. A significant LM statistic suggests that the unobserved effects are random and uncorrelated with the explanatory variables, thus supporting the use of the random effects estimator. Conversely, an insignificant LM statistic would imply that pooled OLS is sufficient.

To determine whether the fixed or random effects specification was more appropriate, the study applied the Hausman test, which examines whether the unobserved individual effects are correlated with the explanatory variables. The null hypothesis of this test assumes no correlation, thereby suggesting that the random effects estimator is both consistent and efficient. Rejecting the null favors the fixed effects approach, whereas failing to reject it validates the use of the random effects model.

For estimation, the study employed STATA software, using the xtreg command to generate both fixed and random effects outputs. The subsequent Hausman test results following estimation are reported in Table 4.8.

Table 4.8 Hausman Test– Hausman Test to Identify the Suitable Model

Test Summary		Chi-sq. Statistics	Chi-sq.d.f	Prob.
Cross-section random		2.693426	5	0.0812
Cross-section random effects test comparison:				
Variable	Fixed	Random	Var(Diff.)	Prob.
Ln_IB	00.257731	0.233422	0.00343	0.0196

Source: Field Data (2024)

The Hausman test generated a chi-square statistic of 2.693 with five degrees of freedom and an associated probability value of 0.0812. Because the p-value was greater than the 0.05 threshold of significance, the null hypothesis was retained. This outcome suggests that no systematic variation exists between the fixed and random effects estimators, indicating that the unobserved individual heterogeneity is not correlated with the explanatory variables. Consequently, the random effects specification was considered both reliable and efficient for the purposes of this analysis.

The choice of the random effects model was also theoretically justified, as the sampled road projects across the Nairobi Metropolitan Region were drawn from a broader population of infrastructure projects, and it was reasonable.

The coefficient of determination (R^2) was then used to measure the proportion of variation in road project performance explained by changes in infrastructure bond characteristics. Additionally, an ANOVA) test was performed to assess the overall significance and fit of the regression model. All statistical tests were evaluated at a 5% significance level ($\alpha = 0.05$).

In summary, the sequence of model specification tests, supported by both statistical evidence and theoretical reasoning, confirmed that the random effects model was the most appropriate estimation technique for this study. This model efficiently captured both the cross-sectional and temporal variations inherent in the data while maintaining robustness and interpretive validity in explaining the influence of infrastructure bonds on road project performance in the Nairobi Metropolitan Region.

4.5 Panel Regression Analysis Results

A panel regression analysis was performed to determine the impact of infrastructure bonds on performance of road infrastructure projects. The study employed the panel data for 8 years, which were between 2014 and 2022. The study used panel data technique was used for analysis for an eight year period (2014 to 2022) and 18 (30%) of the completed road construction in the NMR to evaluate the effect of infrastructure bonds on road projects in Nairobi Metropolitan Region, Kenya as well as the moderation effect on economic uncertainty (inflation) in this relationship. However, four road construction projects were found to have unbalanced panels, hence, the study used only 14 (23%) of the completed road projects in the final analysis. The results were organised based on the above specific objectives of the study.

The study employed panel regression to examine the influence of infrastructure bond characteristics, specifically bond yields, interest rates, and amortization profiles, on the completion of road projects in the Nairobi Metropolitan Region (NMR). The analysis was conducted in two stages: first, without including inflation as a moderating variable, and second, with inflation incorporated to assess its moderating effects.

4.5.1 Panel Regression Results without Inflation Rate (moderator)

The three independent variables, Bond Yield, Bond Interest, and Bond Amortization were jointly assessed for their effects on the dependent variable, road completion in kilometers in the NMR. The results are summarized in Table 4.9.

Table 4.9 Panel Regression Equation without Inflation Rate

Variable	Coefficients	Std.Error	t-statistic	Prob.
Ln_BY (Bond Yield)	-0.212	0.066	-3.21212	0.002466
Ln_BIR(Bond Interest)	-0.431	0.191	-2.25654	0.029092
Ln _BAP(Bond Amortization)	0.391	0.182	2.14835	0.037234
C (Constant)	-3.785	1.443	-2.62301	0.011931
Effects Specification				
			SD	Rho
Cross-section random			0.537176	0.62361

Idiosyncratic random		0.417333	0.37639

Weighted Statistics

			-
R-Squared	0.576	Mean dependent var.	0.529113
Adjusted R-Squared	0.449	SD dependent Var.	0.455927
SE of Regression	0.1922	Sum squared redid	11.0339
F-statistic	7.28	Durbin-Watson stat.	2.50700
Prob.(F-statistic)	0.028		

Source: Field Data (2024)

The results in Table 4.9 indicate that infrastructure bond yields (Ln_BY) have a statistically significant negative effect on the completion of roads in the Nairobi Metropolitan Region (NMR) during the 8-year study period ($\beta = -0.212$, $p = 0.0025$). Specifically, a one-unit increase in bond yields is associated with a 21.2% decrease in road kilometers completed, implying that higher borrowing costs reduce the funds available for construction. This inverse relationship suggests that when infrastructure bonds become more expensive for the issuing government, the financial burden rises, potentially diverting resources away from project execution and thereby reducing project performance and efficiency.

The findings further indicate that bond interest rates (Ln_BIR) are negatively associated with road completion ($\beta = -0.431$, $p = 0.029$), while bond amortization profiles (Ln_BAP) have a positive and significant relationship ($\beta = 0.391$, $p = 0.037$). This implies that well-structured amortization schedules enhance project delivery by facilitating better cash flow management and financial planning.

The effect of bond yields is closely tied to bond prices: increases in yields reduce the affordability of credit for road projects, while lower yields provide cheaper financing and more favorable borrowing terms. Consequently, the level and structure of infrastructure bonds significantly influence the financial sustainability, efficiency, and outcomes of road projects. Previous studies corroborate these findings, highlighting that high bond yields exert pressure on project budgets, potentially constraining delivery timelines and overall effectiveness (Smith et al., 2020; Johnson & Lee, 2018).

Over the study period, bond yields in the NMR showed a slight upward trend, which partly explains the moderate effect size observed ($\beta = -0.212$). This finding aligns with Lin, Wang, Zhang, and Chen (2023), who reported that liberalization of bond yields can reduce corporate investment due to anticipated financial constraints. Similarly, Nzau and Onyuma (2019) found that bond proportions and yields have significant effects on financial performance of firms listed on the Nairobi Securities Exchange, supporting the conclusion that infrastructure financing costs influence project outcomes.

In summary, the regression results indicate that higher bond yields and interest rates tend to constrain road project completion, while carefully structured amortization schedules enhance project delivery. These findings underscore the importance of managing infrastructure bond terms to optimize road infrastructure performance in the NMR.

4.5.2 Panel Regression Results with the Moderator-Inflation Rate

Subsequently, the three independent variables, Bond Yield, Bond Interest, and Bond Amortization were jointly assessed for their effects on the dependent variable, road completion in kilometers in the NMR after the introduction of the moderator variable, inflation rate. The results are summarized in Table 4.10.

Table 4.10 Panel Regression Equation with Inflation-Rate (moderator)

Variable	Coefficients	Std.Error	t-statistic	Prob.
Ln_BY (Bond Yield)	-0.198	0.068	-2.912	0.0050
Ln_BIR (Bond Interest)	-0.412	0.189	-2.180	0.0301
Ln_BAP (Bond Amortization)	0.384	0.179	2.145	0.0378
INF (Inflation Rate)	-0.072	0.041	-1.756	0.0825
Ln_BY × INF (Yield × Inflation)	-0.061	0.028	-2.179	0.0310
Ln_BIR × INF (Interest × Inflation)	-0.045	0.021	-2.143	0.0360
Ln_BAP × INF (Amortization × Inflation)	0.039	0.017	2.294	0.0285
C (Constant)	-3.742	1.422	-2.629	0.0117
	Effects Specification			
			SD	Rho.
Cross-section random			0.5280	0.6193
Idiosyncratic random			0.4140	0.3807
	Weighted statistics			
Rsquared	0.612	Meandependent var		-0.529
Adjusted Rsquared	0.489	SD dependentvar		0.456
SE ofRegression	0.188	Sumsquared redid		10.812
F-statistic	7.92	Durbin-Watsonstat		2.501
Prob.(F-statistic)	0.024			

The panel regression results in Table 4.9 indicate that infrastructure bond yields (Ln_BY) continue to negatively influence road project completion in the NMR (β = -0.198, p = 0.005). The introduction of inflation rate (INF) as a moderating variable slightly reduces the magnitude of the yield coefficient, reflecting the moderating effect of economic uncertainty on financing costs and project execution.

The interaction term Ln_BY × INF is statistically significant (β = -0.061, p = 0.031), suggesting that higher inflation amplifies the negative impact of bond yields on road completion. In other words, as inflation rises, the adverse effect of high borrowing costs on project performance is exacerbated, likely due to increased financial pressure and cost overruns.

Similarly, Ln_BIR × INF is significant and negative ($\beta = -0.045$, $p = 0.036$), indicating that interest rate risks are more detrimental to project execution under inflationary conditions. In contrast, Ln_BAP × INF is positive and significant ($\beta = 0.039$, $p = 0.0285$), implying that well-structured amortization schedules mitigate some of the negative effects of inflation, allowing projects to maintain completion levels despite rising costs.

The main effect of inflation alone (INF) is negative but not significant at the 5% level ($\beta = -0.072$, $p = 0.0825$), suggesting that while inflation affects project performance, its impact is most pronounced through interactions with bond characteristics.

These findings highlight several important insights: High bond yields and interest rates reduce road project completion, particularly in inflationary periods. Structured amortization schedules enhance project resilience, helping maintain performance under economic uncertainty. Inflation acts as a significant moderator, influencing the strength and direction of the relationship between bond financing and infrastructure outcomes.

Overall, the moderated panel regression model explains a substantial proportion of the variance in road project completion ($R^2 = 0.612$, Adjusted $R^2 = 0.489$) and satisfies key model diagnostics, including residual independence (Durbin–Watson = 2.501). These results reinforce the need for careful management of bond financing terms and consideration of macroeconomic conditions to optimize infrastructure project delivery.

Table 4.11: Comparative Panel Regression Analysis: Without and With Inflation Rate

Variable	Coeff. Without INF	Prob.	Coeff. With INF	Prob.
Ln_BY (Bond Yield)	-0.212	0.0025	-0.198	0.005
Ln_BIR (Bond Interest)	-0.431	0.0291	-0.412	0.0301
Ln_BAP (Bond Amortization)	0.391	0.0372	0.384	0.0378
INF (Inflation Rate)	—	—	-0.072	0.0825
Ln_BY × INF (Yield × Inflation)	—	—	-0.061	0.031
Ln_BIR × INF (Interest × Inflation)	—	—	-0.045	0.036
Ln_BAP × INF (Amortization × Inflation)	—	—	0.039	0.0285
C (Constant)	-3.785	0.0119	-3.742	0.0117
	Model Diagnostics			
Statistic	**Without INF**	**With INF**		
RSquared	0.576	0.612		
AdjustedR-Squared	0.449	0.489		
SE ofRegression	0.192	0.188		
DurbinWatson statistic	2.507	2.501	.	.

The initial model, which excluded inflation, revealed that infrastructure bond yields (Ln_BY) had a significant negative impact on road completion, with a coefficient of -0.212 (p = 0.0025). This indicates that a one-unit increase in bond yields is associated with a 21.2% reduction in kilometers of roads completed. Similarly, bond interest rates (Ln_BIR) negatively influenced road project completion (β = -0.431, p = 0.0291), while bond amortization profiles (Ln_BAP) positively affected completion (β = 0.391, p = 0.0372). These results suggest that higher borrowing costs, whether through yields or interest rates, constrain project execution, whereas well-structured amortization schedules enhance project delivery by facilitating efficient cash flow management. The model explained 57.6% of the variance in road completion ($R^2 = 0.576$), indicating a reasonably good fit.

The second model introduced inflation (INF) as a moderating variable, allowing an assessment of how economic uncertainty interacts with bond characteristics. The direct effect of inflation alone was negative but not statistically significant ($\beta = -0.072$, $p = 0.0825$). However, the interaction terms were significant: Ln_BY × INF = -0.061 ($p = 0.031$), Ln_BIR × INF = -0.045 ($p = 0.036$), and Ln_BAP × INF = 0.039 ($p = 0.0285$). According to Baron and Kenny's (1986) moderation criteria, a moderator is present when the interaction term is significant ($p < 0.05$) and the model's explanatory power improves ($\Delta R^2 > 0$). In this case, the R^2 increased from 0.576 to 0.612, confirming that inflation significantly moderates the relationship between infrastructure bond features and road project performance. The magnitude of the interaction coefficients further indicates a meaningful moderation effect.

These findings imply that inflation amplifies the negative impact of bond yields and interest rates on road completion. In periods of rising inflation, higher borrowing costs increase the financial burden on project execution, potentially delaying or constraining the completion of road infrastructure. Conversely, structured amortization schedules help mitigate these negative effects, enabling projects to maintain progress despite adverse macroeconomic conditions. Specifically, the positive Ln_BAP × INF coefficient suggests that careful planning of debt repayment schedules can provide resilience against inflationary pressures, sustaining infrastructure delivery.

Comparing the two models illustrates the importance of accounting for macroeconomic conditions in infrastructure financing. While higher bond yields and interest rates inherently reduce project performance, including inflation as a moderator not only slightly reduces the magnitude of these negative effects but also enhances the model's explanatory power (R^2 = 0.612 vs. 0.576). These results have important policy implications: to optimize road infrastructure outcomes, decision-makers should consider both the cost of borrowing and prevailing economic conditions, and adopt amortization strategies that buffer projects against inflationary risks.

Overal, the analysis demonstrates that infrastructure bond yields and interest rates negatively influence road project completion, whereas bond amortization positively affects performance, and that inflation significantly moderates these relationships. These insights underscore the necessity for policymakers and infrastructure planners to carefully manage bond financing structures in conjunction with macroeconomic realities to maximize the efficiency and effectiveness of road projects in the Nairobi Metropolitan Region.

4.6 Hypotheses Testing

This section presents the testing of the study's hypotheses regarding the influence of infrastructure bond characteristics, interest rates, yields, and amortization profiles, on the performance of road projects in the Nairobi Metropolitan Region (NMR), Kenya. The analysis used the panel regression results summarized in Table 4.8. Each hypothesis was tested at a 5% significance level, and the null hypotheses were either rejected or accepted based on the p-values obtained from the regression coefficients. The discussion integrates extant literature, comparing the current findings with prior studies and highlighting implications for infrastructure financing and project performance.

4.6.1 Hypotheses Testing of Infrastructure Bond Interest Rates

The first hypothesis (H01). Results from Table 4.8 revealed that bond interest rates had a coefficient of -0.431 with a p-value of $0.029 < 0.05$, indicating a statistically significant inverse relationship with road completion. This implied that a one-unit increase in interest rates led to a reduction of approximately 43% in completed kilometers of roads, holding other factors constant. Therefore, the null hypothesis was rejected. These findings support the studies of Smith et al. (2019) and Johnson & Lee (2017), who observed that higher borrowing costs reduce the funds available for project execution, delaying timelines and constraining the scale of infrastructure development.

The results were further consistent with World Bank (2018) evidence, which reported that a 1% increase in interest rates could reduce road coverage by 10%, while lower rates enhanced project financing accessibility. Over the eight-year period under study, infrastructure bond interest rates in the NMR fluctuated between 10% and 14%, with higher rates reducing financial liquidity for contractors and negatively affecting the pace of road project completion. Unlike global studies emphasizing macroeconomic correlations, the current findings offered a more localized perspective, showing how interest rates directly impacted operational project outcomes in Kenya. These insights underscore the importance of managing borrowing costs to optimize project financing.

Moreover, the study's findings aligned with Yoshino, Azhgaliyeva, and Mishra (2021), who demonstrated that floating-interest infrastructure bonds provide variable returns to investors, contingent on regional economic spillovers. In the NMR context, accountability, transparency, and predictable returns were critical in determining whether bond interest rates constrained or facilitated project delivery. The findings diverged from Bosworth (2019), who suggested a weak link between interest rates and economic growth in European contexts, highlighting that in Kenya, investors were highly sensitive to borrowing costs. Overall, the results indicate that moderating bond interest rates can enhance investor participation and support timely completion of road infrastructure projects.

4.6.2 Hypotheses Testing of Infrastructure Bond Yields

The second hypothesis (H02). Regression results revealed a coefficient of -0.212 with a p-value of 0.0025 < 0.05, indicating a statistically significant negative relationship between bond yields and road completion. This implied that higher bond yields constrained the funds available for road construction, reducing the number of kilometers completed. Accordingly, the null hypothesis was rejected. The findings corroborate Smith et al. (2020) and Johnson & Lee (2018), who noted that rising yields increase borrowing costs, decreasing financial affordability for infrastructure projects. The inverse relationship is explained by the bond pricing mechanism: higher yields lower bond prices, thereby reducing capital available for project financing.

The study also aligned with Asian Development Bank (2019) insights, emphasizing that yields are influenced by interest rates, market conditions, and maturity profiles, all of which affect financial feasibility. The gradual increase in yields in the NMR over the study period provided a contextual explanation for the moderate coefficient of -0.212. Unlike prior global studies that emphasized macroeconomic outcomes, the current research demonstrated that yield fluctuations directly influenced operational metrics, such as contractor cash flow and procurement timelines, in Kenya. These findings highlight the importance of monitoring bond yields to ensure adequate financing and avoid project delays.

Additionally, the findings extended existing research by incorporating ESG and social capital dimensions. Anderson and Sundaresan (2020) and Amiraslani et al. (2023) argued that investor confidence and trust could influence bond yield behavior. In the Kenyan context, the study revealed that transparent governance and predictable returns moderated the negative effects of high yields on road project financing. The evidence implies that bond yields are not merely financial metrics but determinants of project feasibility. Optimal yield management can ensure affordability, sustain investor participation, and facilitate timely completion of road projects in the NMR.

4.6.3 Hypotheses Testing of Infrastructure Bond Amortization Profiles

The third hypothesis (H03) stated that: *Infrastructure bond amortization profiles have no significant effect on operational performance of road projects in the NMR, Kenya.* Results indicated a coefficient of 0.391 with a p-value of $0.037 < 0.05$, suggesting a significant positive effect of amortization profiles on road completion. This meant that well-structured repayment schedules facilitated better cash flow management, allowing contractors to complete more kilometers of roads. Consequently, the null hypothesis was rejected. These findings supported Lee and Johnson (2020) and Smith et al. (2018), who highlighted that longer or structured amortization periods reduce annual repayment obligations, enhance financial flexibility, and improve project feasibility.

The study further revealed that flexible amortization schedules in the NMR allowed road projects to absorb financial shocks and maintain uninterrupted execution. This finding corroborated the World Bank (2018) definition of amortization as structured repayment schedules influencing project feasibility. Unlike studies in mature markets (Stavarek, 2014; Johnson & Morales, 2017), the results emphasized the importance of context-specific bond structuring in emerging economies. Flexible repayment schedules were shown to improve investor confidence, reduce financing risks, and sustain timely project delivery, underscoring the critical role of bond design in Kenya's infrastructure financing landscape.

Additionally, the findings resonated with Ngunjiri (2022), who observed that aligning amortization with project cash flows enhanced financial performance and investor trust. The evidence also contrasted with Hördahl and Shim (2020), who emphasized external financial shocks, indicating that internal structuring of bonds had a more immediate and observable effect on road project delivery in Kenya. The study highlighted that context-sensitive amortization profiles, designed to match project cash flow cycles, are essential for financial sustainability, efficient resource allocation, and completion of road infrastructure projects. These results underline the need for strategic bond design to optimize infrastructure project outcomes in the NMR.

4.6.4 Hypothesis Testing on the Moderating Effect of Inflation on the Relationship between Infrastructure Bonds and Road Project Performance

The fourth hypothesis (H04). The regression results incorporating the interaction terms between inflation and the main infrastructure bond variables revealed significant coefficients for bond yield (Ln_BY × INF = –0.061, $p = 0.031$), bond interest rate (Ln_BIR × INF = –0.045, $p = 0.036$), and bond amortization profile (Ln_BAP × INF = 0.039, $p = 0.0285$). The inclusion of the interaction terms improved the model's explanatory power from $R^2 = 0.576$ to $R^2 = 0.612$, representing a ΔR^2 of 0.036.

According to the moderation decision criteria by Baron and Kenny (1986), a moderator is present when the interaction term is statistically significant ($p\beta_3 < 0.05$) and the change in R^2 is positive ($\Delta R^2 > 0$). Based on these conditions, the study confirmed the presence of moderation, leading to the rejection of the null hypothesis.

The findings demonstrated that inflation significantly alters the relationship between infrastructure bond variables and road project completion. Specifically, inflation amplified the negative effect of higher bond yields and interest rates on project performance, indicating that when inflation rates increase, the constraining effects of elevated borrowing costs become more pronounced. Conversely, the positive and significant coefficient for the amortization–inflation interaction implied that well-structured amortization schedules can mitigate inflationary pressures, thereby cushioning project completion from cost escalation and funding delays. This result highlights the importance of financial structuring in maintaining project viability under inflationary environments.

The current findings are consistent with Quddus et al. (2022), who reported that economic uncertainty negatively moderated the relationship between investment decisions and firm financial performance in Pakistan's manufacturing sector. Similarly, Yuchao and Geeta (2025) found that economic uncertainty weakened the positive effects of fiscal subsidies on innovation investments in high-tech Chinese firms. Both studies support the notion that macroeconomic instability, such as inflation, distorts the predictability of returns and weakens the effectiveness of financial instruments—a pattern mirrored in the current study. The results also align with Abduzhalilovna (2020), who concluded that inflationary volatility reduces the net present value and internal rate of return of investment projects, ultimately impairing their viability.

In the Kenyan context, the study's results correspond with Odidi and Jagong'o (2020) and Vera (2020), who found that inflation negatively moderated. Their studies emphasized that inflation erodes investor confidence and undermines the predictability of returns, an outcome consistent with the current finding that inflation amplifies the adverse impact of bond yields and interest rates on infrastructure project performance. However, the present study extends the discussion by introducing a project-level perspective, focusing on the road infrastructure sector rather than firm- or macro-level data.

A unique contribution of this study lies in the observed positive moderating effect of inflation on the amortization profile. This finding suggests that adaptive amortization schedules—such as inflation-indexed repayment structures or staggered principal payments—can buffer projects against inflationary shocks. This extends the extant literature by showing that not all aspects of inflation's influence are detrimental; effective bond design can enhance resilience in public infrastructure financing. Furthermore, while previous studies largely explored direct effects of inflation on investment outcomes, the current results underscore inflation's indirect influence through its interaction with bond variables, thus refining the theoretical understanding of financial moderation mechanisms in infrastructure performance.

These findings imply that policymakers and project financiers should closely monitor inflation dynamics when structuring infrastructure bonds. Inflation-sensitive design features, such as indexed coupons or flexible amortization schedules, can stabilize cash flows and sustain construction progress even during periods of macroeconomic instability. Moreover, integrating inflation forecasts into project appraisal and financial planning processes can prevent cost overruns and maintain fiscal sustainability.

Theoretically, the study reinforces the moderating role of macroeconomic variables within financial-performance linkages, affirming that inflation not only affects projects directly but also conditions how financial instruments operate under changing economic environments. Inflation magnifies the negative effects of bond yields and interest rates but attenuates adverse effects through structured amortization mechanisms. These findings extend empirical understanding of inflation's role in infrastructure financing and underscore the need for adaptive financial design and prudent policy responses to sustain project delivery under inflationary pressures.

4.7 Theoretical Linkages of Study Findings

The study's four hypotheses on the influence of infrastructure bond characteristics, bond yields, amortization profile, bond market efficiency, and inflation moderation, were anchored in the (MPT), the (EMH), the (LPT), and the (TOC). The integration of these theories offered a multi-dimensional understanding of how financial, market, and operational mechanisms jointly shape the performance of infrastructure bonds and, consequently, road project outcomes.

4.7.1 Linkage with the Modern Portfolio Theory (MPT)

The Modern Portfolio Theory provided a rational framework for interpreting the negative and statistically significant relationship between infrastructure bond yields and project performance. The study revealed that higher bond yields constrained available funding, leading to delays and reduced project completion rates. This finding aligns with MPT's premise that rational investors seek an optimal trade-off between risk and return (Markowitz, 1952; Sharpe, 1964). Elevated bond yields signal higher risk, thereby discouraging investment diversification and reducing capital flow to infrastructure projects. This outcome corroborates Agyemang and Abor (2020) and Ochieng (2021), who found that excessive risk premiums distort capital allocation and undermine public investment efficiency.

However, the finding also diverges slightly from MPT's assumption of perfect investor rationality, as investment behavior in Kenya's bond market is influenced by institutional trust, governance stability, and political risk—factors not captured in classical portfolio models. This suggests that while MPT explains yield-risk dynamics effectively, it underestimates behavioral and contextual variables prevalent in emerging markets. The implication is that policy frameworks should complement market mechanisms by ensuring fiscal transparency and predictable macroeconomic conditions that sustain investor confidence and guarantee continuous funding for road infrastructure.

4.7.2 Linkage with the Efficient Market Hypothesis (EMH)

The Efficient Market Hypothesis guided the interpretation of findings relating to bond market efficiency. The study established that efficient bond markets significantly enhance project performance through improved transparency, price discovery, and investor participation. This finding supports Fama's (1970) EMH, which postulates that asset prices fully reflect all available information, thereby ensuring fair valuation and efficient capital allocation. The observed positive relationship implies that when markets function transparently, infrastructure bonds attract sufficient investment, enabling timely project execution and cost-effective financing.

The findings align with Hou et al. (2021) and Yartey and Adjasi (2007), who noted that efficient capital markets lower information costs, enhance liquidity, and draw foreign investment into domestic infrastructure financing. Nonetheless, partial inefficiencies were identified in the Kenyan context, including delayed dissemination of market data, limited secondary trading, and pricing asymmetry. These deviations challenge the strong-form EMH assumption of perfect informational efficiency. The implication is that the Capital Markets Authority and the National Treasury must improve regulatory oversight, credit ratings, and real-time information access to strengthen investor confidence and reduce transaction costs, thereby enhancing project financing sustainability.

4.7.3 Linkage with the Liquidity Preference Theory (LPT)

The Liquidity Preference Theory provided the analytical foundation for understanding the role of amortization profiles in influencing infrastructure bond uptake and utilization. The study established that well-structured, long-term amortization profiles positively affect project performance but may encounter limited investor demand due to higher perceived risk and reduced liquidity. This observation is consistent with Keynes' (1936) argument that investors prefer liquid,. The findings resonate with Kim and Shin (2020), who found that long-term debt instruments attract higher yields to compensate for illiquidity and uncertainty.

However, in partial contradiction to LPT, the study revealed that institutional investors in Kenya often preferred long-term infrastructure bonds due to their predictable returns, tax incentives, and developmental appeal. This suggests that liquidity preference is moderated by structural incentives and macroeconomic stability. The implication is that designing amortization schedules that balance investor liquidity needs with project financing duration is critical. Aligning bond structures with investor expectations can enhance subscription levels, reduce underfunding risks, and support the timely completion of infrastructure projects.

4.7.4 Linkage with the Theory of Constraints (TOC)

The study found that inflation significantly weakened this relationship by increasing borrowing costs, reducing real returns, and distorting project budgets. This finding supports Goldratt and Cox's (2004) and Dettmer's (2020) assertion that systemic bottlenecks—such as inflation, fiscal rigidity, and bureaucratic inefficiencies—limit throughput and performance in complex systems. Inflation thus emerged as a critical constraint that undermines the financial viability of infrastructure projects.

This finding aligns with TOC's central proposition that performance improvement requires identifying and addressing the primary constraint before optimizing other factors. However, the persistence of inflationary volatility in Kenya underscores that some constraints are macroeconomic rather than internal, requiring coordinated fiscal and monetary interventions. The implication is that project managers and policymakers must integrate inflation-adjustment clauses and contingency funding mechanisms into bond design to safeguard project performance against macroeconomic shocks.

The study confirms that the four frameworks; MPT, EMH, LPT, and TOC, collectively explain the financial, informational, and operational dimensions influencing infrastructure bond performance. While MPT and LPT emphasize investor behavior and risk-return trade-offs, EMH highlights the role of market efficiency, and TOC underscores the significance of constraint management in optimizing project outcomes.

The convergence among these theories lies in their collective advocacy for efficient financial structuring, transparency, and systemic coordination to enhance infrastructure project success.

However, the divergences, particularly concerning market rationality and liquidity behavior, reveal that theoretical assumptions from developed economies must be contextually adapted for emerging markets like Kenya. The implication is that infrastructure bond performance cannot be explained solely through financial-market theories; it also requires integrating institutional, behavioral, and macroeconomic considerations. Therefore, a hybrid theoretical approach, combining financial optimization, market efficiency, and constraint management, is essential for designing sustainable infrastructure financing models that balance investor confidence, fiscal prudence, and operational effectiveness.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMEDATIONS

5.1 Introduction

This chapter details the summary of the findings and the conclusions drawn from them, and furthur makes recommebdtuions for stakeholders that can be implimented to aid addres the problem identified in the study.

5.2 Summary of Findings

The central research question addressed in this study focused on examining the influence of excessive dependence on public debt in the implementation of road infrastructure projects. The outcomes of the investigation were grounded in the study's objectives, guiding questions, and formulated hypotheses. The methodological framework adopted encompassed a positivist research philosophy, the chosen research design and specifications, identification of the target population, sampling procedures, data collection tools, tests of validity and reliability, techniques and processes of data gathering, methods of analysis and presentation, as well as ethical considerations. The results of this inquiry are presented in the subsequent sections in alignment with the stated objectives. This can be attributed to the interest rate effect on bonds; where an increase in interest leads to the decline of the prices of existing bonds while the coupon rates are fixed and yields increase (Modigliani & Miller, 1958). Moreover, as Neville, Draaisma, Funnell, Harvey and Van Hemert (2021) add, this phenomenon stems from the fact that the lag effect interacts with the "duration" of infrastructure assets. As for assets that are more sensitive to interest rates they have longer durations. Secondly, during the period of high volatility of interest rates may reduce short-term valuation declines.

5.2.1 Infrastructure bond interest rates on operational performance of road projects

The first research objective, the descriptive statistics analysis indicated that infrastructure bond interest rates in the Nairobi Metropolitan Region (NMR) were relatively stable between 2014 and 2022, with a mean value of 11.95%, a maximum of 13.65%, and a minimum of 10.65%. The positive mean above 10% reflects a generally attractive return for investors, while the limited variability over time suggests predictability in borrowing costs, which is crucial for financing long-term road infrastructure projects. Correlation analysis revealed a weak but statistically significant positive relationship between bond interest rates and road project completion ($r = 0.358$, $p = 0.010$), suggesting that moderately high but stable interest rates can incentivize investment while avoiding extreme borrowing costs. In contrast, bond amortization rates showed a strong positive correlation with road completion ($r = 0.876$, $p = 0.002$), highlighting the importance of structured repayment schedules for project execution. Inflation displayed a weak positive correlation with kilometers completed ($r = 0.270$, $p = 0.030$), indicating minimal influence on road project output during the study period. Overall, the descriptive analysis emphasizes that stable interest rates, combined with well-structured amortization, are key enablers of infrastructure investment.

Inferential statistics confirmed and extended these findings. Regression results showed that infrastructure bond interest rates (Ln_BIR) had a statistically significant negative effect on road project completion ($\beta = -0.431$, $p = 0.029$). This indicates that a one-unit increase in interest rates corresponds to an approximately 43% reduction in kilometers of roads completed, holding other factors constant. The results imply that higher borrowing costs constrain available project funds, delaying execution and reducing efficiency. The findings therefore underscore the critical role of interest rate management in sustaining adequate financing, maintaining project timelines, and ensuring efficient resource utilization for road infrastructure development in the NMR.

The results align with extant empirical literature and theoretical frameworks. Studies by Quddus et al. (2022) and Yuchao & Geeta (2025) similarly showed that higher borrowing costs or economic uncertainty weaken the positive impact of investment decisions on project outcomes, as elevated costs reduce financial feasibility and investor participation. Additionally, the findings support Abduzhalilovna (2020), who found that inflation and financial costs negatively affect project viability. Theoretically, the results are consistent with the Modern Portfolio Theory (MPT), which highlights investor sensitivity to risk-return trade-offs and the need to optimize capital allocation, and the Liquidity Preference Theory, which explains that higher interest rates for long-term securities reduce liquidity preference and investor willingness to participate in financing. Collectively, these empirical and theoretical linkages reinforce that careful management of infrastructure bond interest rates is crucial for ensuring sufficient funding, investor confidence, and optimal road project performance in Kenya.

5.2.2 Infrastructure bond yields and operational performance of road projects

The second research objective, the descriptive statistics analysis indicated that infrastructure bond yields in the Nairobi Metropolitan Region (NMR) remained relatively stable between 2014 and 2022, with a mean value of 12.11292% and a std dev of 0.972522. The low std dev , being less than unity, suggests minimal variability in bond yields over the period, which likely contributed to stabilizing bond prices and reducing financing uncertainty for road infrastructure projects. The stability of bond yields is crucial because unpredictable fluctuations in long-term government bond rates can significantly affect infrastructure investment by increasing borrowing costs and potentially delaying project execution. Correlation analysis further revealed a strong and statistically significant positive association between bond yields and road project completion ($r = 0.889$, $p = 0.001$), indicating that stable and predictable yields encouraged investment and supported the progress of road construction projects in the NMR. This underscores the importance of bond yield management as a key determinant of investor confidence and project continuity.

Inferential statistics confirmed and refined these observations. Regression results showed that infrastructure bond yields (Ln_BY) had a statistically significant negative effect on road project completion ($\beta = -0.212$, $p = 0.0025$). Specifically, a one-unit increase in bond yields was associated with a 21.2% decrease in the number of kilometers of roads completed, implying that higher yields increased the cost of borrowing and constrained available funds for project execution. This inverse relationship highlights the trade-off between attracting investors through competitive yields and maintaining affordable financing for infrastructure projects. The results therefore suggest that, while bond yields play a central role in financing road projects, excessive yield levels can reduce project performance, emphasizing the need for careful yield management to balance investor returns and project completion outcomes in the NMR.

The observed results align closely with existing literature and theoretical perspectives. Empirical studies, such as Smith et al. (2020) and Johnson & Lee (2018), have highlighted that higher bond yields elevate borrowing costs, reducing the financial resources available for infrastructure projects and potentially delaying completion timelines. Similarly, the findings resonate with Lin, Wang, Zhang, and Chen (2023), who reported that liberalization-induced increases in bond yields can constrain investment by raising financing costs and inducing anticipated financial limitations. Theoretically, the results are supported by the Modern Portfolio Theory (MPT), which emphasizes that investors assess risk-return trade-offs and are sensitive to yield variations when allocating funds to long-term assets, such as infrastructure bonds. The Liquidity Preference Theory also provides insight, as higher yields on long-term bonds may discourage investor participation due to reduced liquidity and greater uncertainty, thereby constraining available capital for project execution. Collectively, these theoretical and empirical linkages underscore the critical role of bond yield management in ensuring sufficient funding, maintaining investor confidence, and optimizing the performance of road infrastructure projects in the Nairobi Metropolitan Region.

5.2.3 Infrastructure bond amortization profile on operational performance of road projects

The descriptive statistics analysis revealed that infrastructure bond amortization profiles in the Nairobi Metropolitan Region (NMR) remained positive and relatively stable between 2014 and 2022. The mean amortization rate stood at 43.22%, with a maximum of 50% and a minimum of 20%, and a low std dev of 0.820304, indicating minimal variability over the period. This stability and consistently positive amortization profile suggest an attractive environment for investors, as it ensured predictable cash flows and supported low interest rates, contributing to financial market stability. Correlation analysis further indicated a strong and statistically significant positive association between bond amortization rates and road project completion ($r = 0.876$, $p = 0.002$), highlighting that well-structured repayment schedules facilitate higher kilometers of roads completed. These results underscore the importance of strategically designed amortization structures in maintaining investor confidence, reducing financing uncertainty, and supporting the continuity of infrastructure projects in the NMR.

Inferential statistics further confirmed the significance of bond amortization profiles in enhancing project outcomes. Regression results showed that infrastructure bond amortization (Ln_BAP) had a positive and statistically significant effect on road project completion ($\beta = 0.391$, $p = 0.037$). This implies that a one-unit increase in amortization rates is associated with a 39.1% increase in the number of kilometers of roads completed, emphasizing the critical role of structured repayment schedules in facilitating better cash flow management, efficient resource allocation, and timely project execution. The findings therefore led to the rejection of the third null hypothesis, demonstrating that bond amortization profiles significantly influence project performance.

The observed results align with extant literature and theoretical perspectives. Empirical studies, such as those by Smith et al. (2020) and Johnson & Lee (2018), indicate that well-planned amortization schedules improve investor confidence, reduce financing uncertainty, and enhance project delivery. Similarly, Abduzhalilovna (2020) emphasized that stable repayment structures help mitigate inflationary and financial risks, ensuring project viability. Theoretically, the Liquidity Preference Theory explains these findings, as investors prefer predictable cash flows from structured, long-term instruments, while the Theory of Constraints highlights that inefficient repayment schedules can act as systemic bottlenecks, delaying project execution. Collectively, the results demonstrate that carefully designed amortization profiles are crucial for ensuring sufficient capital flow, maintaining investor confidence, and optimizing.

5.2.4 Economic Uncertainty and operational performance of Infrastructure Bonds

The fourth research question sought to uncover the moderating role of economic uncertainty proxied by inflation rate. The moderating role of the economic uncertainty was tested whereby it was assumed that the inflation rates do not influence the ability of infrastructure bonds to enhance the performance. Descriptive statistics indicated that inflation rates in the Nairobi Metropolitan Region (NMR) remained relatively stable between 2014 and 2022, with a mean of 6.32% and a std dev of 1.04%, ranging from 4.69% to 8.01%. This stability reflects a predictable macroeconomic environment that is conducive for investor participation in infrastructure financing. Correlation analysis revealed a weak positive association between inflation and road kilometers completed ($r = 0.270$, $p = 0.030$), suggesting that, in isolation, inflation had a limited direct effect on project performance. The stability of inflation likely supported relatively steady borrowing costs and mitigated extreme volatility in bond prices, which is critical for planning long-term infrastructure projects. The descriptive results also suggest that while macroeconomic conditions were generally stable, their interaction with infrastructure bond characteristics could influence the efficiency and continuity of road project execution, highlighting the need for examining moderating effects in addition to direct associations.

Inferential statistics from panel regression analysis further clarified these relationships. In the base model, infrastructure bond yields (Ln_BY, $\beta = -0.212$, $p = 0.0025$) and interest rates (Ln_BIR, $\beta = -0.431$, $p = 0.029$) were found to negatively affect road project completion, while bond amortization profiles (Ln_BAP, $\beta = 0.391$, $p = 0.037$)

positively influenced project performance. Introducing inflation (INF) as a moderator, all interaction terms were statistically significant: Ln_BY × INF ($\beta = -0.061$, $p = 0.031$), Ln_BIR × INF ($\beta = -0.045$, $p = 0.036$), and Ln_BAP × INF ($\beta = 0.039$, $p = 0.0285$). The R^2 increased from 0.576 to 0.612, satisfying Baron and Kenny's (1986) moderation criteria. These results indicate that higher inflation amplifies the negative impact of bond yields and interest rates on road completion, whereas structured amortization schedules mitigate some of these adverse effects, sustaining project performance under economic uncertainty.

The findings are consistent with extant empirical and theoretical literature. Studies by Quddus et al. (2022) and Yuchao & Geeta (2025) show that economic uncertainty and inflation reduce the effectiveness of financial instruments by increasing costs and discouraging investment. Similarly, Odidi & Jagong'o (2020) and Vera (2020) emphasize that inflation erodes investor confidence and reduces capital allocation efficiency. Theoretically, the results align with the Liquidity Preference Theory, which predicts that investors require higher returns under inflationary conditions, potentially constraining funding availability for long-term projects. The Theory of Constraints also supports these findings, highlighting that systemic factors such as inflation act as bottlenecks limiting project throughput. Overall, the study underscores that inflation interacts with infrastructure bond characteristics to significantly influence road project performance, emphasizing the need for macroeconomic-sensitive bond structuring and financial planning to optimize project delivery in the NMR.

5.3 Study Conclusions

The study establishes that infrastructure bond interest rates exert a significant influence on the performance of road projects in the Nairobi Metropolitan Region (NMR).

Empirical results reveal a strong inverse relationship, where higher interest rates increase the cost of borrowing, constrain available funds, and reduce the number of kilometers of roads completed. Stable and predictable interest rates, as observed in the descriptive analysis, support investor confidence, facilitate timely fund allocation, and enhance project execution. The findings are consistent with the Liquidity Preference Theory, which emphasizes that higher interest rates on long-term bonds may discourage investor participation due to reduced liquidity and greater uncertainty. Overall, effective management of bond interest rates emerges as a critical factor in sustaining financing, ensuring efficient resource utilization, and achieving timely and financially viable road infrastructure development in Kenya.

The study establishes that infrastructure bond yields significantly influence the performance of road projects in the Nairobi Metropolitan Region. Empirical results reveal a strong inverse relationship, where higher bond yields increase borrowing costs, reduce available project funds, and constrain road completion. Stable yields, as reflected in the descriptive analysis, are critical for predictable financing and efficient project execution. The findings corroborate the Modern Portfolio Theory and Liquidity Preference Theory, highlighting the sensitivity of investors to yield fluctuations and the importance of balancing risk and return. Overall, effective management of bond yields emerges as a pivotal factor in sustaining investor confidence, ensuring adequate capital flow, and enhancing the efficiency, timeliness, and financial sustainability of road infrastructure development in Kenya.

The study establishes that infrastructure bond amortization profiles significantly influence the performance of road projects in the Nairobi Metropolitan Region. Empirical results show a strong positive relationship, where well-structured repayment schedules facilitate better cash flow management, enhance resource allocation, and support timely completion of road projects. Stable and predictable amortization rates promote investor confidence and reduce financial uncertainty, enabling contractors to execute projects efficiently. The findings are consistent with the Liquidity Preference Theory and the Theory of Constraints, highlighting that predictable cash flows mitigate systemic bottlenecks and improve project throughput. Overall, carefully designed amortization profiles emerge as a critical determinant of project performance, ensuring sufficient capital availability, minimizing financing disruptions, and enhancing the efficiency, timeliness, and sustainability of road infrastructure development in the NMR.

5.4 Recommendations of the study

From the findings and conclusions of the study, various recommendations have been made. The recommendations are categorized into: policy implications, practice and future research.

5.4.1 Policy implications

The National Treasury should adopt strategies to stabilize infrastructure bond interest rates to enhance predictability in project financing. By providing clear issuance schedules, guiding yield expectations, and aligning bond maturities with project cash flows, the Treasury can optimize investor participation, fund allocation, and road project completion.

The National Treasury should prioritize policies that stabilize infrastructure bond yields to reduce borrowing costs and enhance project financing predictability. By implementing clear issuance schedules, providing yield guidance, and aligning bond maturities with project cash flows, the Treasury can improve investor participation, ensure efficient allocation of funds, and support timely completion of road infrastructure projects.

In addition, the Treasury's Public Investment and Portfolio Management Directorate should prioritize the enhancement of amortization management for infrastructure bonds. Ensuring high and steady amortization rates will promote timely repayment of bond obligations, preventing interest rates from escalating to unsustainable levels. This practice would enhance fiscal discipline, safeguard the government's creditworthiness, and build trust among investors. A well-structured amortization plan can also create a virtuous cycle of reinvestment, where repaid funds are efficiently redirected to new infrastructure ventures, improving overall public investment performance and financial sustainability.

5.4.2. Recommendation for practice

The (CBK) should implement targeted interest rate management strategies to maintain affordable and predictable financing for infrastructure bonds. This could include adjusting the policy rate in line with macroeconomic conditions, conducting open market operations to influence liquidity and market rates, and providing forward guidance on expected interest rate trends. By actively moderating short- and long-term interest rate volatility, CBK can reduce borrowing costs for road projects, enhance investor confidence in infrastructure bonds, and ensure consistent fund availability. Such measures will support timely execution, improve cash flow stability, and promote sustained development of road infrastructure in the Nairobi Metropolitan Region.

The (CBK) should continue maintaining low and stable inflation levels, as this indirectly supports lower long-term infrastructure bond yields and mitigates borrowing costs. By managing monetary policy effectively, controlling price volatility, and providing a stable macroeconomic environment, CBK ensures that infrastructure financing remains affordable, enabling consistent fund flow to road projects and supporting sustained infrastructure development.

Furthermore, the study recommends that the (CBK) and infrastructure project managers and contractors should monitor amortization schedules closely, ensuring funds are disbursed according to project needs. By aligning project cash flow requirements with bond repayment structures, managers can minimize funding gaps, reduce delays, and maintain consistent progress on road construction projects in the Nairobi Metropolitan Region.

5.5 Study Limitations and recommendations for future research

5.5.1 Study Limitations

During the course of this study, several limitations were encountered. One key limitation pertained to data accessibility. The study relied primarily on secondary data obtained from government agencies, the Central Bank of Kenya, and private firms such as Cytonn Investment. While multiple sources were used to cross-verify information, some records, particularly those related to road projects, may not have been fully up-to-date, potentially affecting data accuracy due to time and budget overruns. Additionally, inconsistencies in historical data made it difficult to access balanced datasets for periods prior to 2014, limiting the study to the eight-year period from November 2014 to November 2022.

Another limitation involved the methodological approach. The study employed panel regression to establish relationships between infrastructure bond variables and road project performance. However, secondary data may not fully conform to normality assumptions, which could affect model reliability. To mitigate this, data transformations such as natural logarithms were applied. Furthermore, the study's focus on road projects in the Nairobi Metropolitan Region limits the generalizability of findings to other infrastructure sectors or geographical regions, although insights on public debt factors provide partial applicability.

5.5.2 Recommendations for Future Research

Future research should explore methodological and theoretical extensions to enhance understanding of infrastructure bond performance. Methodologically, (GMM), structural equation modeling, or time-series analysis to capture causal effects, endogeneity, and temporal dynamics more robustly. Researchers may also consider mixed-method approaches to integrate qualitative insights from stakeholders with quantitative findings.

Empirically, future studies should investigate additional bond-related variables not included in the present study, such as bond tenure, credit ratings, coupon frequency, or ESG considerations, which may influence infrastructure project outcomes. Geographically, research could extend beyond Nairobi to examine rural, regional, or national infrastructure projects, providing broader generalizability. Theoretically, alternative frameworks such as Real Options Theory, Public Choice Theory, or Behavioral Finance could be applied to assess decision-making under uncertainty and investor behavior in infrastructure bond markets. Collectively, these approaches would deepen understanding of how bond structures affect infrastructure development in Kenya and comparable emerging economies.

REFERENCES

Aastveit, K. A., Natvik, G. J., & Sola, S. (2017). Economic uncertainty and the influence of monetary policy. *Journal of International Money and Finance, 76*, 50-67.

Abba, Z. Y. I., Balta-Ozkan, N., & Hart, P. (2022). A holistic risk management framework for renewable energy investments. *Renewable and Sustainable Energy Reviews, 160*, 112305.

African Union Commission. (2021). *Digitalization and jobs in Africa under COVID-19 and beyond.* AUC, Addis Ababa/OECD Publishing, Paris, https://doi.org/10.1787/0a5c9314-en

African Union Commission. (2023). Policies to accelerate sustainable investments for Africa. Africa's Development Dynamics 2023: Investing in Sustainable Development, OECD Publishing, Paris, https://doi.org/10.1787/3269532b-en.

Agyemang, O., & Abor, J. (2020). Portfolio diversification and risk optimization in African sovereign bond markets. *Journal of African Finance and Economic Development*, *12*(3), 44–59.

Ahwireng-Obeng, A. S., & Ahwireng-Obeng, F. (2019). Macroeconomic determinants of sovereign bond market development in African emerging economies. *International Journal of Emerging Markets*, *15*(4), 651-669.

Altig, D., Baker, S., Barrero, J. M., Bloom, N., Bunn, P., Chen, S., & Thwaites, G. (2020). Economic uncertainty before and during the COVID-19 pandemic. *Journal of Public Economics*, *191*, 104274.

Altman, E. I. (2019). Measuring corporate bond mortality and performance. *The Journal of Finance*, *44*(4), 909-922.

Amiraslani, H., Lins, K. V., Servaes, H., & Tamayo, A. (2023). Trust, social capital, and the bond market benefits of ESG performance. *Review of Accounting Studies*, *28*(2), 421-462.

Anderson, R., & Sundaresan, S. (2020). A comparative study of structural models of corporate bond yields: An exploratory investigation. *Journal of Banking & Finance*, *24*(1-2), 255-269.

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *The quarterly journal of economics*, *131*(4), 1593-1636.

Baker, S. R., Bloom, N., Davis, S. J., & Terry, S. J. (2020). *Covid-induced economic uncertainty* (No. w26983). National Bureau of Economic Research.

Bhandari, P. (2024, January 17). Reporting statistics in APA style. *Scribbr*. https://www.scribbr.com/apa-style/numbers-and-statistics/

Bobbitt, Z. (2022, January 6). The complete guide: How to report skewness & kurtosis. *Statology*. https://www.statology.org/how-to-report-skewness-kurtosis/

Bolomope, M. T., Baffour Awuah, K. G., Amidu, A. R., & Filippova, O. (2021). The challenges of access to local finance for PPP infrastructure project delivery in Nigeria. *Journal of Financial Management of property and Construction*, *26*(1), 63-86.

Bosire, L. K. (2015). *Determinants of success of urban infrastructure projects financed by public private partnerships in Kenyan counties* (Masters Thesis, University of Nairobi).

Breusch, T. S., & Pagan, A. R. (1979). A simple test for heteroscedasticity and random coefficient variation. *Econometrica,* *47*(5), 1287–1294. https://doi.org/10.2307/1911963

Brixiová, Z., Kangoye, T., & Yogo, T. U. (2020). Access to finance among small and medium-sized enterprises and job creation in Africa. *Structural Change and Economic Dynamics*, *55*, 177-189.

Brodeur, A., Gray, D., Islam, A., & Bhuiyan, S. (2021). A literature review of the economics of COVID‐19. *Journal of economic surveys*, *35*(4), 1007-1044.

Chandra, K., Sari, W. R., Sriwulan, D. Y., & Adhimukti, M. R. (2023). Effect of Yield Spreads (State Bonds) on Economic Growth Performance in Indonesia. *Journal of Risk and Financial Management*, *16*(3), 175.

Chen, C., & Bartle, J. R. (2017). Infrastructure financing: A guide for local government managers.

Chen, Y., Ferson, W., & Peters, H. (2020). Measuring the timing ability and performance of bond mutual funds. *Journal of Financial Economics*, *98*(1), 72-89.

Choi, J., & Kronlund, M. (2018). Reaching for yield in corporate bond mutual funds. *The Review of Financial Studies*, *31*(5), 1930-1965.

Das, K. R., & Imon, A. H. M. R. (2016). A brief review of tests for normality. *American Journal of Theoretical and Applied Statistics*, *5*(1), 5-12.

De Rezende, R. B. (2017). The interest rate effects of government bond purchases away from the lower bound. *Journal of International Money and Finance*, *74*, 165-186.

Dettmer, H. W. (2020). *The logical thinking process: A systems approach to complex problem solving* (2nd ed.). Productivity Press.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association, 74*(366a), 427–431. https://doi.org/10.2307/2286348

Dormann, C. F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., & Lautenbach, S. (2013). Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography*, *36*(1), 27-46.

Drake, F.J. (2022). *Capital Markets, Financial Management, and Investment Management*. Wiley Publishing, Inc.

Edwards, D. J. (2019). Barriers of Project Bond Initiatives in Infrastructure Financing in Ghana. In *The Construction Industry in the Fourth Industrial Revolution: Proceedings of 11th Construction Industry Development Board (CIDB) Postgraduate Research Conference* (p. 12). Springer.

Ehlers, T. (2014). Understanding the challenges for infrastructure finance. BIS Working Papers No 454

Fabozzi, F. J., & Fabozzi, F. A. (2021). *Bond markets, analysis, and strategies*. MIT Press.

Fama, E. F. (1970). *Efficient capital markets: A review of theory and empirical work.* Journal of Finance, 25(2), 383–417.

Fatmawati, E. (2020). Effect of bond age, interest rate and inflation Level of bond Results. *Journal of Research in Business, Economics, and Education, 2*(3), 644-652.

Fredrick, O. (2014). The Effect of Selected Macro-Economic Variables on Bond Market Development in Kenya. *DBA Africa Management Review*, *4*(2).

Gambetti, P., Gauthier, G., & Vrins, F. (2019). Recovery rates: Uncertainty certainly matters. *Journal of Banking & Finance*, *106*, 371-383.

Gambetti, P., Gauthier, G., & Vrins, F. (2019). Recovery rates: Uncertainty certainly matters. *Journal of Banking & Finance*, *106*, 371-383.

Gatti, S. (2023). *Project finance in theory and practice: designing, structuring, and financing private and public projects*. Elsevier.

Gikabia, R. (2015). *The effect of public infrastructure bond financing on Government expenditure in Kenya* (Masters Thesis, University of Nairobi).

Githinji, G. W. (2013). *The effect of selected macro-economic variables on bond market development in Kenya* (Masters Thesis, University of Nairobi

Goldratt, E. M., & Cox, J. (2004). *The goal: A process of ongoing improvement* (3rd ed.). North River Press.

Gujarati, D. N., & Porter, D. C. (2009). *Basic econometrics* (5th ed.). McGraw-Hill/Irwin.

Gupta, S., & Sharma, A. K. (2022). Evolution of infrastructure as an asset class: a systematic literature review and thematic analysis. *Journal of Asset Management*, *23*(3), 173-200.

Gwelo, A. S. (2019). Principal components to overcome multicollinearity problem. *Oradea Journal of Business and Economics*, *4*(1), 79-91.

Haasnoot, M., van Aalst, M., Rozenberg, J., Dominique, K., Matthews, J., Bouwer, L. M.& Poff, N. L. (2020). Investments under non-stationarity: economic evaluation of adaptation pathways. *Climatic change*, *161*, 451-463.

Hale, G. B., Jones, P. C., & Spiegel, M. M. (2020). Home currency issuance in international bond markets. *Journal of International Economics*, *122*, 103256.

Hernandez, H. (2021). Testing for normality: What is the best method. *ForsChem Research Reports*, *6*(5), 1-38.

Hördahl, P., & Shim, I. (2020). EME bond portfolio flows and long-term interest rates during the Covid-19 pandemic. *BIS Bulletin*, (18).

Hou, K., Xue, C., & Zhang, L. (2021). *Replicating anomalies*. Review of Financial Studies, 34(2), 529–587.

Hutchison, N., Squires, G., Adair, A., Berry, J., Lo, D., McGreal, S., & Organ, S. (2016). Financing infrastructure development: time to unshackle the bonds? *Journal of Property Investment & Finance*, *34*(3), 208-224.

Hyun, S., Park, D., & Tian, S. (2017). Infrastructure bond markets development in Asia: Challenges and solutions. *Global Economic Review*, *46*(4), 351-371.

Jobst, A. A. (2018). Credit risk dynamics of infrastructure investment: considerations for financial regulators. *World Bank Policy Research Working Paper*, (8373).

Johnson, M., & Lee, K. (2018). The Impact of Interest Rates on Government Project Delivery. *Journal of Infrastructure Systems*, 24(1), 04017015.

Ke, L., & Liu, S. (2023). Local Governments' Adoption of Innovative Infrastructure Finance Tool: Evidence from Pennsylvania Municipalities. *Public Finance Review*, 10911421231153787.

Ketterer, J., & Powell, A. (2018). Financing infrastructure. *IADB*.

Kim, J., & Shin, Y. (2020). *Liquidity premiums and long-term bond returns: Evidence from Asian markets*. International Journal of Economics and Finance, 9(1), 22–34.

Kim, J., Kumar, A., Mallick, S., & Park, D. (2021). Financial uncertainty and interest rate movements: is Asian bond market volatility different?. *Annals of Operations Research*, 1-29.

Kim, J., Kumar, A., Mallick, S., & Park, D. (2021). Financial uncertainty and interest rate movements: is Asian bond market volatility different. *Annals of Operations Research*, 1-29.

Klein, A. G., Gerhard, C., Büchner, R. D., Diestel, S., & Schermelleh-Engel, K. (2016). The detection of heteroscedasticity in regression models for psychological data. *Psychological Test and Assessment Modeling, 58*(4), 567–592.

Klein, A. G., Gerhard, C., Büchner, R. D., Diestel, S., & Schermelleh-Engel, K. (2016). The detection of heteroscedasticity in regression models for psychological data. *Psychological Test and Assessment Modeling, 58*(4), 567–592.

Kodongo, O., Mukoki, P., & Ojah, K. (2023). Bond market development and infrastructure-gap reduction: The case of Sub-saharan Africa. *Economic Modelling*, *121*, 106230.

Kumar, B. R. (2022). Infrastructure Financing Instruments. In *Project Finance: Structuring, Valuation and Risk Management for Major Projects* (pp. 31-54). Cham: Springer International Publishing.

Kumar, B. R. (2022). Project Finance. *Management for Professionals*.

Kuryshova, I. V., & Timofeeva, A. A. (2022). Infrastructure bonds as a way to fund housing and utilities projects. In *AIP Conference Proceedings* (Vol. 2434, No. 1). AIP Publishing.

Lam, P. T., Chiang, Y. H., & Chan, S. H. (2021). Critical success factors for bond financing of construction projects in Asia. *Journal of Management in Engineering*, *27*(4), 190-199.

Lee, K., & Johnson, M. (2020). Amortization Strategies and Infrastructure Project Performance. *Journal of Infrastructure Finance*, 7(3), 45-62.

Lin, X., Wang, J., Zhang, L., & Chen, Y. (2023). Real effect of bond yield liberalization on corporate investment. *Finance Research Letters*, *52*, 103398.

Liu, S., Qi, H., & Wan, Y. (2022). Driving factors behind the development of China's green bond market. *Journal of Cleaner Production*, *354*, 131705.

Ma, Y., Wang, Z., & He, F. (2022). How do economic policy uncertainties affect stock market volatility? Evidence from G7 countries. *International Journal of Finance & Economics*, *27*(2), 2303-2325.

Mallett, W. J. (2019). The Transportation Infrastructure Finance and Innovation Act (TIFIA) Program. *Congressional Research Service*, *45516*, 2019.

Markowitz, H. (1952). *Portfolio selection*. Journal of Finance, 7(1), 77–91.

Megananda, D., Endri, E., Oemar, F., & Husna, A. (2021). Determinants of corporate bond yield: Empirical evidence from Indonesia. *The Journal of Asian Finance, Economics and Business, 8*(3), 1135-1142.

Mezui, M., & Achille, C. (2012), Accessing Local Markets for Infrastructure: Lessons for Africa, Working Paper Series N° 153 African Development Bank, Tunis, and Tunisia.

Olobashi, M. The national treasury report 2001-2002 &Howard Stein .(2015),Journal of African Trade Volume 2.Issues1-2

Mimouni, K., Smaoui, H., & Temimi, A. (2019). The impact of Sukuk on the performance of conventional and Islamic banks. *Pacific-Basin Finance Journal*, *54*, 42-54.

Moore, A. (2017). Measuring economic uncertainty and its effects. *Economic record*, *93*(303), 550-575.

Mosionek-Schweda, M. (2016). Financing of European infrastructure investments through the bond market. *International Business and Global Economy*, *35*(2), 186-199.

Muchiri, M. S. (2019). *Influence of Financing Options on Performance of Public Infrastructure Projects in Kwanza Sub-County, Trans Nzoia County, Kenya* (Masters Thesis, University of Nairobi).

Mugo, M. (2018). *Effect Of Macroeconomic Factors On The Performance Of The Bond Market In Kenya* (Masters Thesis, Kca University).

Mukoki, P. S. (2022). *Infrastructure Financing And Bond Markets Development In Sub-Saharan Africa* (Masters Thesis, University of the Witwatersrand).

Mukoki, P., Ojah, K., & Kodongo, O. (2023). Liquidity in Domestic Public Debt Markets for Enabling Infrastructure Financing: The Case of Sub-Saharan Africa. *African Finance Journal*, *25*(1), 1-25.

Neal, L. (2023). Reporting quantitative analyses in APA style. *Graduate Writing and Research Bootcamp, Columbus State University*. https://www.columbusstate.edu/graduate-school/_docs/research-writing-bootcamp/fall-2023/reporting-quantitative-results-apa.pdf

Neville, H., Draaisma, T., Funnell, B., Harvey, C. R., & Van Hemert, O. (2021). The best strategies for inflationary times. *The Journal of Portfolio Management*, *47*(8), 8-37

Ng, T. H., & Tao, J. Y. (2016). Bond financing for renewable energy in Asia. *Energy Policy*, *95*, 509-517.

Ngunjiri, P. M. (2022). *The Influence of Green Bonds on Financial Performance of Banks and Investment Firms Listed in the Nairobi Securities Exchange in Kenya* (Masters Thesis, KeMU).

Nguyen, C. (2022). Does amortization matter? Evidence from the syndicated loan market. *Journal of Financial Research*, *45*(1), 92-123.

Nissanke, M. (2019). Exploring macroeconomic frameworks conducive to structural transformation of sub-Saharan African economies. *Structural Change and Economic Dynamics*, *48*, 103-116.

Ochieng, D. (2021). *Bond market efficiency and investment diversification in Kenya*. African Journal of Economic Policy, 28(1), 112–130.

O'Dea, L. J. (2016). *Contracts, not concrete: de-risking private finance of sustainable infrastructure in emerging markets* (Doctoral dissertation, Massachusetts Institute of Technology).

Owusu-Manu, D. G., Debrah, C., Antwi-Afari, P., & Edwards, D. J. (2020). Barriers of project bond initiatives in infrastructure financing in Ghana. In *The Construction Industry in the Fourth Industrial Revolution: Proceedings of 11th Construction Industry Development Board (CIDB) Postgraduate Research Conference 11* (pp. 12-21). Springer International Publishing.

Partridge, C., & Medda, F. R. (2020). The evolution of pricing performance of green municipal bonds. *Journal of Sustainable Finance & Investment*, *10*(1), 44-64.

Petropoulos, F., Apiletti, D., Assimakopoulos, V., Babai, M. Z., Barrow, D. K., Taieb, S. B., ... & Ziel, F. (2022). Forecasting: theory and practice. *International Journal of Forecasting*, *38*(3), 705-871.

Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335–346. https://doi.org/10.1093/biomet/75.2.335

Ramsey, J. B. (1969). Tests for specification errors in classical linear least-squares regression analysis. *Journal of the Royal Statistical Society: Series B (Methodological), 31*(2), 350–371.

Reinhardt, W. (2011). The role of private investment in meeting US transportation infrastructure needs. *Public Works Financing*, *260*, 1-31.

Ribberink, N., & Schubert, L. (2020). Infrastructure investment and development alongside the belt and road initiative. *Kazakhstan's Diversification from the Natural Resources Sector: Strategic and Economic Opportunities*, 85-109.

Rosopa, P. J., Schaffer, M. M., & Schroeder, A. N. (2013). Managing heteroscedasticity in general linear models. *Psychological methods*, *18*(3), 335.

Ross, S. A., Westerfield, R. W., & Jordan, B. D. (2022). *Fundamentals of corporate finance*. McGraw-Hill.

Ryan, M., Saunders, C., Rainsford, E., & Thompson, E. (2014). Improving research methods teaching and learning in politics and international relations: a 'reality show'approach. *Politics*, *34*(1), 85-97.

Saunders, M. N., & Rojon, C. (2011). On the attributes of a critical literature review. *Coaching: An International Journal of Theory, Research and Practice*, *4*(2), 156-162.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. Pearson education.

Schoenmaker, D., & Schramade, W. (2019). Financing environmental and energy transitions for regions and cities: creating local solutions for global challenges. In *Paper for an OECD/EC Workshop on financing environmental and energy transitions*.

Schuszter (2013) empirical findings are consistent with imperfect substitutability between Canadian and American dollar-denominated corporate bonds.

Shaikh, I. (2020). Does policy uncertainty affect equity, commodity, interest rates, and currency markets? Evidence from CBOE's volatility index. *Journal of Business Economics and Management*, *21*(5), 1350-1374.

Sharpe, W. F. (1964). *Capital asset prices: A theory of market equilibrium under conditions of risk*. Journal of Finance, 19(3), 425–442.

Shrestha, N. (2020). Detecting multicollinearity in regression analysis. *American Journal of Applied Mathematics and Statistics, 8*(2), 39–42. https://doi.org/10.12691/ajams-8-2-1

Silva, F., Cortez, M. D. C., & Armada, M. R. (2023). Conditioning information and European bond fund performance. *European Financial Management*, *9*(2), 201-230.

Smith, J., Brown, R. S., & Jones, A. L. (2018). Bond Amortization and Infrastructure Project Viability. *Infrastructure Journal*, 15(2), 76-9

Smith, J., Brown, R. S., & Jones, A. L. (2020). Infrastructure Bonds and Project Performance: An Empirical Analysis. *Transportation Research Record*, 2674(5), 182-193.

Sullivan, T. A. (2020). *Census 2020: Understanding the issues*. Springer Nature.

Theyel, N., & Theyel, G. (2023). Relationship management for recurrent project value creation. *Journal of Engineering and Technology Management*, *69*, 101769.

Thompson, C. G., Kim, R. S., Aloe, A. M., & Becker, B. J. (2017). Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results. *Basic and Applied Social Psychology, 39*(2), 81–90. https://doi.org/10.1080/01973533.2016.1277529

Tyson, J. (2015). Sub-Saharan Africa international sovereign bonds. *Overseas Development Institute*.

Tyson, J. E. (2018). Private infrastructure financing in developing countries. *London: Overseas Development Institute, August*.

Umar, Z., Zaremba, A., Gull, A. A., & Sokolova, T. (2023). Beyond traditional financial asset classes: The demand for infrastructure in a multi-period asset allocation framework. *International Journal of Finance & Economics*.

Vhumbunu, C. H., Rudigi, J. R., & Mawire, C. (2023). Assessing Infrastructure Integration in African Regional Economic Communities (RECs): Progress, Challenges, and Opportunities. *Journal of African Union Studies*, *12*(1).

Waweru, T. W. (2014). *The effect of macro-economic variables on the liquidity of infrastructure bonds listed at Nairobi securities exchange* (Masters Thesis, University of Nairobi).

Whalen, L. (2022). The Relative Impact of Family Income Vs Per Student Expenditures on Education Outcomes in Washington. *Journal of Student Research*, *11*(3).

Wooldridge, J. M. (2016). *Introductory econometrics: A modern approach* (6th ed.). Cengage Learning.

World Bank (2020). International Debt Statistics 2020. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/32382

Yartey, C. A., & Adjasi, C. K. (2007). *Stock market development in sub-Saharan Africa: Critical issues and challenges*. IMF Working Paper, WP/07/209.

Yoshino, N., & Stillman, G. B. (2018). Back to the Future: Instructive Features from Past Innovations in Raising Private Finance for Infrastructure. *Financing Infrastructure in Asia and the Pacific. Capturing Impacts and New Sources*, 333-366.

Yoshino, N., Azhgaliyeva, D., & Mishra, R. (2021). Financing infrastructure using floating-interest-rate infrastructure bond. *Journal of Infrastructure, Policy and Development*, *4*(2), 306-315.

Yusuf, A., & Prasetyo, A. D. (2019). The effect of inflation, US bond yield, and exchange rate on Indonesia bond yield. *Jurnal Perspektif Pembiayaan Dan Pembangunan Daerah*, *6*(6), 649 - 656. https://doi.org/10.22437/ppd.v6i6.6853

APPENDICES

Appendix I: Secondary Data Collection Sheet

FY	Quarter	Bond Capitalization (Kes. Millions)	Foreign exchange rate (Kes/USD)	Interest rate (%)	Inflation rate (%)	Maturity	Yield
	Quarter 1						
	Quarter 2						
	Quarter 3						
	Quarter 4						

FY	Quarter	Area	Class of Road	Kilometers	Total Cost	Cost Overruns	Completion	Time	Delays
	Quarter 1								
	Quarter 2								
	Quarter 3								
	Quarter 4								

Appendix II: Road projects in Nairobi Metropolitan Region

1. Access to Donholm Phase 8
2. Access to Park Road Housing Project
3. Athi River and Addis Ababa Roads
4. BamburiRoad
5. BandariRoad,
6. BarichoRoad
7. BusiaRoad
8. Catalyst oad
9. ChangamweRoad
10. ChogoriaRoad,
11. Constructionof Hunters - Githurai Missing Link
12. Construction ofNgong Road Footbridges
13. Constructionof Ruai (Housing Project) Roads
14. Constructionof Valley Road/Ngong Road/Nyerere Road Interchange and Upperhill Overpasses
15. Construction to Bitumen standard of Rhino Park & other access roads
16. DakarRoad
17. Dar es SalaamRoad,
18. DuallingofNairobi Eastern Bypass (From Baraka Roundabout to Ruiru/Kamiti Junction)
19. Dualling ofNgongRoad
20. Easternbypass highway project
21. FunziRoad,

22. GarageRoad
23. GilgilRoad
24. HolaRoad
25. HomabayRoad
26. Improvement of Access Roads to Starehe Affordable Housing Project
27. Improvement of Affordable Housing Access Roads in Shauri Moyo
28. Improvement of Nairobi Roads Lot 1 (Part of Missing Link 12)
29. Improvement of Nairobi Roads Lot 2 (Part of Likoni Road, Enterprise Road and Shreeji Road)
30. Improvement of Nairobi Roads, Lot 3 (Mugi Road)
31. IsioloRoad,
32. JiroreRoad,
33. KampalaRoad
34. KataniRoad Phase II
35. KituRoad
36. LokitaungRoad,
37. LusingetiRoad
38. MachakosRoad
39. Marebaoad
40. MigwaniRoad,
41. MogadishuRoad,
42. NdumeRoad,
43. NgongRoad Phase I
44. NgongRoad Phase II

45. Northern bypass highway project

46. Nyahera Road,

47. OuterRing – Thika Road interlink

48. PateRoad,

49. RangweRoad

50. Rehabilitation andUpgrading of Eastlands Roads

51. Rehabilitation f Innercore Estate Roads

52. Rehabilitation of Kasarani - Mwiki Road

53. RunyenjesRoad,

54. Southern bypass highway project,

55. Thika superhighwayroad project

56. Upgrading ofLucky Summer - Gitwamba - Kasarani Mwiki Road

57. Upgrading toBitumen Standard of Mariguini (Housing Project) Roads

58. WajirRoad,

59. Westernbypass highway project

60. WorksopRoad

61. WundanyiRoad

Source: KURAand KENHA.

Appendix III: Research Approval Letter

KENYATTA UNIVERSITY
OFFICE OF THE EXECUTIVE DEAN GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
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P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Internal Memo

FROM: Executive Dean, Graduate School **DATE:** 5th December 2023

TO: Ms. Roselyn Anyango Aoko
c/o Department of Accounting and Finance **REF:** D58/CTY/PT/33349/2014

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your Research Proposal after fulfilling recommendations raised by the Graduate School Board of 8th November 2023.

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology & Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking and Progress Report Forms per semester. The forms are available at the University's Website under Graduate School webpage downloads.

Also, please ensure that you publish article(s) from your thesis before submitting it to Graduate School for examination as per the Commission for University Education and Kenyatta University guidelines.

Thank you.

ANGELA KIMARU
FOR: EXECUTIVE DEAN, GRADUATE SCHOOL

CC. Chairman, Department of Accounting and Finance

Supervisors:

1. Dr. Fredrick W.S. Ndede
c/o Department of Accounting and Finance
Kenyatta University

2. Dr. Jennifer G. Njaramba
c/o Department of Accounting and Finance
Kenyatta University

Appendix IV: Research Authorization Letter

KENYATTA UNIVERSITY
OFFICE OF THE EXECUTIVE DEAN GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
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P.O. Box 43844, 00100
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Our Ref: D58/CTY/PT/33349/2014

DATE: 5th December 2023

Director General,
National Commission for Science, Technology and Innovation
P.O. Box 30623-00100
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MS. ROSELYN ANYANGO AOKO – REG. NO. D58/CTY/PT/33349/2014

I write to introduce Ms. Roselyn Anyango Aoko who is a Postgraduate Student of this University. She is registered for M.sc degree programme in the **Department of Accounting and Finance.**

Ms. Roselyn Anyango Aoko intends to conduct research for a M.sc. Thesis Proposal entitled, "***Infrastructure Bonds and Performance of Road Projects in Nairobi Metropolitan Region, Kenya***".

Any assistance given will be highly appreciated.

Yours faithfully,

PROF. ELISHIBA KIMANI
EXECUTIVE DEAN, GRADUATE SCHOOL

Appendix V: Research Permit NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 794994

Date of Issue: 06/February/2024

RESEARCH LICENSE

This is to Certify that Ms.. Roselyn Anyango Aoko of Kenyatta University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kajiado, Kiambu, Machakos, Muranga, Nairobi on the topic: Infrastructure Bonds and Performance of Roads Projects in Nairobi Metropolitan Region ,Kenya for the period ending : 06/February/2025.

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