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MEDIATING EFFECT OF DELIVERY CAPABILITY ON PUBLIC-PRIVATE PARTNERSHIP FINANCING STRUCTURE AND GEOTHERMAL ENERGY DEVELOPMENT PROJECT COMPLETION IN KENYA

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ABSTRACT: *Investments in Geothermal Energy Development Projects (GEPs) are still considered high-risk and capital-intensive with unpredictable completion even amidst the adoption of Public Private Partnership (PPP) financing models particularly in sub-Saharan Africa (SSA). Numerous GEP completion bottlenecks affecting timely project completion have been documented lately; these challenges have caused delayed delivery of critical path milestones, project stalling, and even outright project failures. Recent empirical studies focused more on developed countries' longitudinal secondary databases covering the wider energy sector, with minimal attention paid to the situation of GEPs in developing countries. Anchored on the positivism and pragmatism foundations, this study examined the mediating influence of delivery capability on the relationship between PPP financing structure and the completion of GEPs in Kenya. Using a census survey design, data from 48 geothermal energy projects (private sector project managers and implementation team leaders from the public sector) and key informants was collected and analyzed using mixed methods. Data triangulation and diagnostic tests were performed. The results and findings revealed that while PPP financing structure alone explains 43.9% of the variance in project completion, the inclusion of delivery capability substantially increases the explained variance to 66.1%. A balanced PPP financing structure and delivery capability have statistically significant effects on project completion outcomes, with delivery capability (β = 0.579) having a stronger isolated effect than the PPP financing structure (β = 0.326). The reduction in the PPP financing structure coefficient from the first to the second model suggests that some of its effect is shared with or mediated by delivery capability. The study concluded that completing PPP-financed GEPs requires an integrated approach that considers both predictor variables: A balanced PPP financing structure comprising private equity, commercial and concessional loans, grants and government contributions; and strong delivery capability including geological, technological, PPP modelling and agile project management competencies. Geothermal sector-specific government support measures and industry recommendations are provided to enhance the completion of PPP-financed geothermal energy development projects mainly in the SSA region.*

KEYWORDS: Delivery Capability; Public-Private Partnership (PPP); Financing Structure; Project Completion; Geothermal Energy Development Project (GEP); Mediating Effect.

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INTRODUCTION

Kenya's emergence as Africa's leading geothermal energy producer marks a significant achievement in the continent's sustainable energy transition agenda. Geological surveys in the Rift Valley during the 1950s culminated in the commissioning of the Olkaria I geothermal power plant in 1981 albeit with significant technical challenges (Omenda & Simiyu, 2015). Following the unbundling of sector institutional mandates in 2006 through the Energy Act 2006 (Sessional Paper Number 4 on Energy of 2004), remarkable progress has been recorded in the resource assessment, exploration, and development of the geothermal fields (Ngugi, 2019); the installed geothermal capacity has significantly increased from a mere 45 MW in 1995 towards the 1000MW club target with a projection of reaching 1200 MW in 2023, thereby contributing around 38% to the nation's electricity generation (Kiplagat et al., 2021). Despite these successes, the substantial financial burden of geothermal projects, with individual wells costing USD 3-6 million (and no guaranteed success) and large-scale power plants exceeding USD 300 million in investment (Waswa & Juma, 2020), has necessitated innovative financing strategies, primarily through the Independent Power Producer (IPP) variant of PPPs. Although the country’s geothermal potential is estimated at 10,000 MW, it requires substantial capital investment and targeted government support measures to develop the remaining 9000 MW (Mariita, 2018).

The PPPs are increasingly recognized as essential instruments for bridging infrastructure financing gaps, particularly in developing economies, by effectively combining public and private sector resources and expertise (World Bank, 2020). Their application in geothermal energy offers several key advantages: the sharing of inherent project risks, access to specialized technical expertise from the private sector, enhanced financial innovation through diverse funding sources, and a stronger commitment to long-term project sustainability (Kumar & Pratap, 2019; Li et al., 2020; Chen & Wang, 2021; Hassan et al., 2019). The successful Olkaria III project, Africa's first privately funded geothermal power plant, exemplifies the potential of well-structured PPPs to mobilize private capital under appropriate public sector oversight (Mwangi, 2020). Comparative studies further indicate that countries employing PPP frameworks in renewable energy projects achieve significantly higher completion (approximately 30% higher) compared to those relying solely on public funding (Thompson et al., 2022). However, the success of such partnerships remains contingent upon several critical factors, including efficient risk allocation, robust legal frameworks, and strong institutional capacity (Zhang & Chen, 2021).

This study directly addresses the need to better understand the complex relationship between PPP financing structures and project completion in Kenya's geothermal sector, with a specific focus on the mediating influence of delivery capability. This nuanced understanding is crucial for optimizing future project designs and for enhancing the overall completion metrics of geothermal energy development in developing economies pursuing similar strategies. The following sections focus on a comprehensive investigation of the relationship between public-private partnerships (PPPs), financing structures, delivery capability, and project completion in geothermal energy projects in Kenya. Through a mixed-methods research design, the study examines existing literature, conducts descriptive, quantitative and qualitative data analysis, and discusses results and findings before outlining practical implications, conclusions, and recommendations. The research aims to provide valuable insights for policymakers, investors, and project managers to improve the efficiency and effectiveness of geothermal energy development.

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LITERATURE REVIEW

The Dynamic Capability Theory (DCT), introduced by Teece, Pisano, and Shuen (1997), provides a robust framework for understanding how organizations adapt and thrive in rapidly changing environments. This theory is particularly relevant to the context of geothermal energy development projects in Kenya, where complex PPP financing structures and evolving market conditions necessitate adaptive organizational capabilities. Dynamic capabilities are defined as "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece et al., 1997). In the context of geothermal energy projects, these capabilities can be categorized into three main clusters, namely: sensing, being the ability to identify and assess opportunities and threats in the sector; seizing, being the capacity to mobilize resources and capture value from identified opportunities; and transforming, being the continuous renewal and modification of resources and operational capabilities (agility). Helfat and Peteraf (2009) further elaborated on the concept, emphasizing that dynamic capabilities enable organizations to alter their resource base, creating new strategies for value creation. In the context of PPP-financed geothermal projects, this could involve adapting strategic project management approaches and community benefit-sharing mechanisms, reconfiguring resource allocations, or innovating financing strategies in response to project challenges or market shifts. Recent studies have applied DCT to the energy sector; for instance, Zhong and Wu (2020) examined how dynamic capabilities influence the performance of renewable energy firms, finding that sensing and seizing capabilities significantly impact firm innovation and market performance.

An ideal PPP financing structure: It does not only meet immediate funding requirements but also guarantees the long-term health and sustainability of the project life cycle (Du et al., 2019). Unlike the concept of capital structure, which is limited to debt and equity aspects, a PPP financing structure encompasses a blend of distinct sources of project financing in varying dimensions, amounts, terms, and conditions; ranging from government and private sector equity, commercial and concessional loans, hybrid or mezzanine finance, and grants from government/ and development partners.

Risk allocation in PPP financing: Effective risk allocation is crucial for PPP success. Grimsey and Lewis (2002) identify key risks in PPP projects, including construction risk, operational risk, and market risk. In geothermal projects, geological risk is particularly significant (Ngugi, 2012). The World Bank (2017) emphasizes that optimal risk allocation assigns risks to the party best equipped to manage them. Critical success factors for PPP projects have been extensively studied; Osei-Kyei and Chan (2015) conducted a comprehensive review, where they identified enabling factors such as appropriate risk allocation, strong private consortium, political support, public acceptance, and transparent procurement practices.

Delivery capability: In the context of energy projects, this concept can be understood as a set of dynamic competences specific to project execution. Technical capability refers to the specialized knowledge and skills required for geothermal energy development; Kagel (2008) highlights the importance of geological expertise, drilling technology, and power plant engineering in geothermal projects. Management capability encompasses project planning, coordination, and control; Jergeas (2008) emphasizes the importance of integrated project management approaches in large-scale energy projects. Resource mobilization capability involves the ability to secure and deploy financial, human, and material resources effectively;

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Toksoy et al. (2010) discuss the challenges of resource mobilization in geothermal projects, particularly in developing countries.

Project completion: The concept of project completion is principally founded on the public choice theory underpinnings and systems approach to project life cycle management, especially for complex development projects; even amidst implementation challenges, an ideal development project must have a definite start and an end (Bonnal et al., 2002; Rose & Indelicato, 2009). Critical success factors influencing project completion in energy projects include effective project management, stakeholder engagement, risk management, technical expertise, and financial stability. Project completion outcomes have been typically measured by time performance (adherence to schedule), cost performance (adherence to budget), quality performance (meeting technical specifications), and scope fulfilment. Chan and Chan (2004) propose a comprehensive framework for measuring project success, including both objective and subjective measures; Ruuska et al. (2011) specifically examine success factors in large-scale energy projects, emphasizing the importance of knowledge integration and stakeholder alignment.

The situation in Kenya: According to the Geothermal Development Company (GDC, 2023), while Kenya is acknowledged as the largest geothermal power producer in Africa, the installed geothermal capacity has reached about 860 MW translating into a paltry 9% of the estimated 10,000 MW potential. The country's Geothermal Master Plan aims to increase this capacity to 5,000 MW by 2030 (Ministry of Energy, Kenya, 2022). Despite significant progress, geothermal development in Kenya faces several challenges; the mega projects are capital-intensive and highly risky, particularly in the exploration and drilling phases (Omenda et al., 2020); uncertainties in resource assessment and exploration success rates pose significant risks to developers (Ngugi, 2012); an ongoing need for specialized skills and knowledge in geothermal technology (Mariita, 2015); and the projects must navigate complex environmental regulations and community engagement issues (Ogola et al., 2012). The Kenyan government has prioritized geothermal development in its energy policy (Ministry of Energy, Kenya, 2022). Key agencies have advanced collaborations with international development organizations and private sector partners to benefit from the potential knowledge transfer and investment (Musembi, 2014).

Conceptual model: Based on the literature reviewed, a conceptual framework developed posits that “PPP financing structures influence project completion ouctomes, but this relationship is mediated by delivery capability”; that is, the effectiveness of PPP financing structures in ensuring project completion is contingent on the strength of delivery capability. Dynamic capabilities theory underpins the framework, suggesting that organizations with stronger adaptive capabilities are better equipped to leverage PPP financing for successful project completion. The sub-variables of PPP financing structure were measured in terms of availability, accessibility, affordability, and amounts while completion facets were measured using more sector-specific technical, financial, social, and environmental metrics. Project governance, organization agility, contract management, and benefits management were sub-variables of delivery capability; they were measured in terms of decision-making effectiveness, funds absorption rate, contractor capacity, and risk allocation using the 5-point Agree-Disagree (A-D) Likert scale of agreement. This conceptual framework provided a basis for empirical investigation into the complex relationships between financing structures, organizational capabilities, and project outcomes in the context of Kenyan geothermal energy development.

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RESEARCH METHODOLOGY

This study employed a mixed-methods research design, combining quantitative and qualitative approaches to comprehensively address the research problem. The design incorporated a non-experimental descriptive cross-sectional survey for quantitative data collection and key informant interviews for qualitative insights. The research design was rooted in positivism and pragmatism, utilizing both quantitative and qualitative methods to provide a holistic examination of the research problem. A cross-sectional survey was conducted to collect quantitative data from primary respondents, while key informant interviews were carried out to gather qualitative data from secondary respondents. This approach allowed for the collection of both numerical data for statistical analysis and in-depth perspectives on the study themes. The study focused on 48 Geothermal Energy Projects (GEPs) licensed in Kenya by the Energy and Petroleum Regulatory Authority (EPRA) as of June 30, 2023. Given the manageable size of the population, a census approach was adopted. The target primary respondents consisted of 96 individuals, comprising 48 project managers from the private sector and 48 project implementation team leaders from the public sector. Additionally, 19 senior managers and directors from relevant public, private, development, research, and academic organizations were targeted as key informants for qualitative data collection. Quantitative data was collected through structured questionnaires administered to project managers and implementation team leaders. The questionnaires utilized a 5-point Likert scale (Agree-Disagree) for categorical responses. Qualitative data was gathered using a Key Informant Interview (KII) Guide for secondary respondents. Secondary data was obtained through a critical review of relevant literature and internet content. The primary research instruments comprised a structured questionnaire and a Key Informant Interview (KII) Guide. An observation checklist was also used when site visits were possible. These instruments were designed to capture both quantitative and qualitative data relevant to the study objectives. Quantitative data analysis involved both descriptive and inferential statistics. Diagnostic tests were conducted to determine the absence of multicollinearity, autocorrelation, abnormality, and heteroskedasticity.

Descriptive statistics included measures of central tendency and dispersion. The inferential analysis primarily utilized correlation and an integrated linear regression model to examine the relationships between PPP financing structures, delivery capability, and project completion. Qualitative data was analyzed using content reduction and thematic analysis techniques. Data triangulation was employed to integrate quantitative and qualitative findings, enhancing the credibility and comprehensiveness of the results. To ensure the validity and reliability of the study, several measures were taken. A pilot study was conducted on a PPP-financed wind power project, employing a test-retest method. Internal consistency was assessed using Cronbach's alpha analysis, with a threshold of $\alpha \geq 0.9$ considered excellent. Content validity was evaluated using the Content Validation Index (CVI) and face validity was established through consultation with subject matter experts. The research instruments underwent refinement based on feedback from supervisors, sector experts, and peers. The study adhered strictly to ethical guidelines, including university regulations and applicable laws, as well as the global best practices regarding academic research ethics. Informed consent was obtained from all participants, and measures were taken to ensure anonymity and confidentiality. The research purpose was clearly explained to all participants at the outset. Where necessary, permission was sought for field photos and observations. This comprehensive methodology

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enabled the collection of rich, diverse data, allowing for a nuanced analysis of PPP financing structure and their impact on geothermal energy project completion in Kenya

RESULTS AND FINDINGS

The study examined the mediating effect of delivery capability on the relationship between public-private partnership (PPP) financing structure and the completion of geothermal energy development projects in Kenya. The analysis aimed to test the null hypothesis (H03) that delivery capability has no significant mediating influence on this relationship. A hierarchical regression analysis was conducted to investigate the relationships among PPP financing structure, delivery capability, and project completion. The analysis yielded two prediction models:

Model 1 (PPP Financing Structure only): The results showed a strong positive correlation between PPP financing structure and project completion ($R = 0.663$). PPP financing structure alone explained 43.9% of the variance in project completion ($R^2 = 0.439$). The model was statistically significant ($F = 72.114$, $p < 0.001$).

Model 2 (PPP Financing Structure and Delivery Capability): The inclusion of delivery capability strengthened the correlation ($R = 0.813$) and substantially increased the explained variance to 66.1% ($R^2 = 0.661$). The R^2 change of 0.222 indicated that delivery capability accounted for an additional 22.2% of the variance in project completion. This model also demonstrated statistical significance ($F = 88.778$, $p < 0.001$).

The linear regression equations derived from the analysis were:

Model 1: Project Completion = 0.624 + 0.875 * PPP Financing Structure; and

Model 2: Project Completion = -0.132 + 0.430 * PPP Financing Structure + 0.633 * Delivery Capability.

In Model 2, both predictors showed statistically significant effects ($p < 0.001$). The standardized coefficients (Beta) revealed that delivery capability ($\beta = 0.579$) had a stronger unique effect on project completion compared to the PPP financing structure ($\beta = 0.326$). The analysis also indicated acceptable levels of multicollinearity (Tolerance = 0.662, VIF = 1.512), suggesting that while PPP financing structure and delivery capability are related, they represent distinct constructs contributing uniquely to project completion. Tables 1, 2, and 3 indicate the findings.

Table 1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.663	.439	.433	.51307			1	92	.000
2	.813	.661	.654	.40108	.222	59.548	1	91	.000

Source: *Olando et al. (2024)*

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Table 2: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
1 (Regression)	18.983	1	18.983	72.114	.000
1 (Residual)	24.218	92	.263		
1 (Total)	43.201	93			
2 (Regression)	28.562	2	14.281	88.778	.000
2 (Residual)	14.639	91	.161		
2 (Total)	43.201	93			

Source: *Olando et al. (2024)*

Table 3: Coefficients

Model	Variable	B (Unstandardized Coefficient)	Std. Error	Beta (Standardized Coefficient)	t	Sig.
1	(Constant)	0.624	0.397		1.575	0.119
	PPP Financing Structure	0.875	0.103	0.663	8.492	0.000
2	(Constant)	-0.132	0.325		-0.406	0.686
	PPP Financing Structure	0.430	0.099	0.326	4.346	0.000
	Delivery Capability	0.633	0.082	0.579	7.717	0.000

Source: *Olando et al. (2024)*

Key informant interviews provided additional stakeholder perspectives on the critical delivery capabilities influencing geothermal energy development projects in Kenya. The most consistently emphasized capability was technical expertise in geothermal exploration and development. This finding underscores the technical complexities and resource-intensiveness of geothermal projects, where accurate resource assessment, appropriate power plant design, and effective drilling management are crucial for success (Mwaura, 2016). Other significant capabilities highlighted by informants included: project management skills; financial management and structuring capabilities; stakeholder engagement and management; and environmental and social impact management. Results from data triangulation indicated a nexus between the qualitative and quantitative findings. The results provide strong evidence for the mediating role of delivery capability in the relationship between PPP financing structure and geothermal project completion. The substantial increase in explained variance (from 43.9% to 66.1%) when adding delivery capability to the model underscores its critical importance. The analysis also indicated acceptable levels of multicollinearity (Tolerance = 0.662, VIF = 1.512), suggesting that while PPP financing structure and delivery capability are related, they represent distinct constructs contributing uniquely to project completion.

The reduction in the PPP financing structure coefficient from Model 1 to Model 2 (0.875 to 0.430) suggests that some of its effect is shared with or mediated by delivery capability. This indicates that while PPP financing is important, its effect on project completion is partially explained by its relationship with delivery capabilities (Delmon, 2015). The larger standardized coefficient for delivery capability (0.579) compared to the PPP financing structure (0.326) in Model 2 suggests that implementation skills may be even more critical than financing

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arrangements for project success. This aligns with research emphasizing the importance of project management and execution in complex energy projects (DiPippo, 2016). These findings highlight the need for a comprehensive approach to geothermal energy development, considering both PPP financing structure and implementation capabilities. The results suggest that while robust PPP financing arrangements are necessary, they are not sufficient for ensuring project success. Building strong and or agile project delivery capabilities, particularly in technical areas specific to geothermal development, is equally if not more important for achieving high completion outcomes in these complex infrastructure development projects.

DISCUSSION

The study examined the mediating influence of delivery capability on the relationship between public-private partnership (PPP) financing structure and the completion of geothermal energy development projects in Kenya. The analysis aimed to test the null hypothesis (H03) that delivery capability has no significant mediating influence on this relationship. The results of this study provide strong evidence for the mediating role of delivery capability in the relationship between public-private partnership (PPP) financing structure and the completion of geothermal energy development projects in Kenya. The key findings are: PPP financing structure alone explained 43.9% of the variance in project completion, which underscores the importance of financing arrangements in project success; the inclusion of delivery capability in the model substantially increased the explained variance to 66.1%, indicating that delivery capability accounted for an additional 22.2% of the variance in completion; the regression analysis showed that both PPP financing structure and delivery capability had statistically significant effects on project completion outcomes. However, delivery capability ($\beta = 0.579$) had a stronger unique effect compared to the PPP financing structure ($\beta = 0.326$); and the reduction in the PPP financing structure coefficient from the first to the second model (0.875 to 0.430) suggests that some of the effect of financing structure is shared with or mediated by delivery capability.

These findings build upon and extend the existing literature on PPP financing and project implementation in the energy sector. Prior research has emphasized the importance of both financing arrangements and project management capabilities for successful energy project delivery (Delmon, 2015; DiPippo, 2016). The results of this study validate and quantify the critical mediating role of delivery capability, particularly in the context of complex geothermal energy projects. These findings underscore the need for a comprehensive approach to geothermal energy development that considers both PPP financing structures and project delivery capabilities. The results suggest that while robust PPP financing arrangements are necessary, they are not sufficient for ensuring project success. The findings can inform policy and practice related to geothermal energy development, highlighting the need for targeted capacity-building initiatives and the integration of financing and implementation considerations in project planning and execution.

This study contributes to the theoretical understanding of the relationships between PPP financing, delivery capability, and project performance in the energy sector. Specifically, it extends existing theories on the role of PPP financing structures and delivery capabilities in complex project implementation by empirically demonstrating the mediating effect of delivery capability. The findings suggest that delivery capability should be considered as a distinct and

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critical construct in theoretical models of energy project success, rather than being subsumed under broader project management concepts. The insights from this study can inform the design and structuring of PPP agreements for geothermal energy projects, highlighting the need to allocate resources and attention to both financing and delivery capability development. The findings can guide capacity-building initiatives and training programs for project teams involved in geothermal energy development, with a focus on strengthening technical, project, and stakeholder engagement skills. The results can support policy decisions and regulatory frameworks related to geothermal energy, emphasizing the need for a holistic approach that addresses both financing and implementation considerations. The study provides a model for how delivery capability can be empirically assessed and integrated into performance monitoring and evaluation systems for energy projects.

CONCLUSION AND RECOMMENDATIONS

This study examined the mediating effect of delivery capability on the relationship between public-private partnership (PPP) financing structure and the completion of geothermal energy development projects in Kenya. While PPP financing structures are important for the success of geothermal energy development projects, they are not sufficient on their own. Building strong and or agile delivery capabilities, particularly in technical areas specific to geothermal, is equally if not more critical for achieving high completion outcomes. Successful geothermal energy development requires a multi-faceted set of capabilities, including technical expertise, project management, financial structuring competencies, stakeholder engagement, and environmental and social impact management strengths. Based on the results and findings, the null hypothesis that delivery capability has no significant mediating influence on the relationship between PPP financing structure and the completion of GEPs in Kenya is rejected.

The study suggests that policymakers should integrate delivery capability assessments into the evaluation and selection criteria for geothermal energy PPP projects. Additionally, they should develop targeted capacity-building programs and training initiatives to strengthen the technical, managerial, and stakeholder engagement skills of project teams involved in geothermal energy development. Incorporating delivery capability considerations into policy and regulatory frameworks governing the geothermal energy sector is also recommended. The study further recommends that industry players should ensure that PPP agreements for geothermal energy projects allocate adequate resources and attention to the development of delivery capabilities, in addition to financing arrangements. Establishing robust performance monitoring and evaluation systems that track financial, technical, and socio-environmental indicators together with delivery capability metrics for geothermal energy projects is also advised.

Collaboration with policymakers and academic institutions to identify and address critical skill gaps in the geothermal energy industry is encouraged. The study acknowledges that the findings may not be directly generalizable to other countries or regions, as the research was conducted in the Kenyan context. Also, the population, while adequate for the statistical analysis, could be expanded to enhance the robustness of the results. The study suggests that future research should replicate the study in other countries or regions to explore the consistency and generalizability of the findings. Investigating the relationship between delivery capability and project completion in other types of energy or infrastructure development projects is advisable. Conducting in-depth qualitative studies to further explore the specific

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components and dynamics of delivery capability in the context of geothermal energy development is encouraged. Developing and testing theoretical models that integrate PPP financing structures, delivery capabilities, and other contextual factors as determinants of energy project completion is also suggested.

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