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INTEGRATING OPTIMIZATION MODELS INTO PUBLIC SECTOR PERFORMANCE EVALUATION: EVIDENCE FROM NIGERIAN PUBLIC INSTITUTIONS

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ABSTRACT

Public sector institutions in Nigeria operate under severe fiscal constraints, rising service delivery demands, and increasing pressure for accountability. Performance evaluation systems in many public organizations, including federal universities, ministries, and agencies, remain primarily descriptive and compliance-driven, limiting their usefulness for strategic decision-making. This study examines the integration of Operations Research (OR) optimization models into public-sector performance evaluation, with specific reference to Nigerian public institutions, such as federal universities. Using insights from linear programming, data envelopment analysis, and goal programming, the study develops a conceptual framework linking performance indicators to optimization-based decision support. The paper argues that embedding optimization models into performance evaluation systems can improve resource allocation, enhance operational efficiency, and strengthen accountability in Nigerian public institutions. The study contributes to public management and applied economics literature by demonstrating how optimization techniques can transform performance evaluation from a reporting exercise into a strategic management tool in developing economies.

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1. Introduction

Public sector performance evaluation has become a central concern in Nigeria due to persistent inefficiencies, fiscal constraints, and rising public scrutiny of government resource use. Over the past decades, declining real budgetary allocations, macroeconomic instability, and rising operational costs, particularly for energy, personnel, and infrastructure maintenance, have placed significant pressure on government-funded institutions. At the same time, citizens and oversight bodies are demanding higher standards of service delivery, transparency, and value for money from public organizations. These pressures have intensified debates over how performance in the Nigerian public sector should be assessed, managed, and improved sustainably (Ofoegbu, 2014).

Government-funded institutions such as federal universities, teaching hospitals, and regulatory agencies are expected to deliver high-quality services despite operating under severe resource constraints. In the Nigerian higher education sector, universities such as the University of Lagos and the University of Ibadan illustrate these challenges clearly. These institutions contend with overcrowded lecture halls, deteriorating physical infrastructure, inadequate laboratory and research facilities, staff shortages, and unstable funding flows, all of which undermine teaching quality, research output, and administrative efficiency (Saint et al., 2003; Okebukola, 2015). The mismatch between growing student enrolment and stagnant or declining funding further exacerbates inefficiencies and limits universities' ability to fulfil their core mandates.

Performance evaluation mechanisms in Nigerian public institutions have traditionally focused on compliance-oriented criteria, including adherence to financial regulations, audit outcomes, procurement procedures, and input-based indicators such as budget utilization rates, personnel numbers, and capital expenditure execution. While these measures are essential for ensuring probity and preventing the misuse of public funds, they are largely retrospective and emphasize whether rules were followed rather than whether resources were used effectively to generate desired outcomes (Adegoroye, 2006; Ohemeng, 2010). Consequently, performance evaluation often functions primarily as an ex post control and sanctioning mechanism, offering limited insights into how scarce resources can be reallocated or managed differently to improve service delivery, productivity, and social impact.

This limitation is particularly problematic in complex public institutions where managers must

balance multiple, and sometimes conflicting, objectives such as access, quality, equity, and cost containment. Without analytical tools that explicitly address trade-offs and constraints, decision-making tends to rely on incremental budgeting, historical allocations, or political considerations, rather than evidence-based optimization. As a result, inefficiencies persist, and opportunities for performance improvement remain largely unexplored.

Operations Research (OR) and optimization models provide a rigorous and systematic approach to decision-making under conditions of scarcity and competing objectives, making them especially relevant for the public sector. Techniques such as linear programming, goal programming, and data envelopment analysis (DEA) allow decision-makers to model resource constraints, define performance objectives, and identify efficient frontiers or optimal allocation strategies. Although these methods have been widely applied in private-sector efficiency analysis and performance management, their adoption in Nigerian public sector institutions, particularly for routine performance evaluation and planning, remains limited (Oladejo & Oluwaseun, 2019). Where they are used, applications are often ad hoc, research-driven, or disconnected from formal management and budgeting processes.

Integrating optimization models into public sector performance evaluation, therefore, offers a strategic opportunity to bridge the gap between performance measurement and actionable decision-making. By embedding key performance indicators, such as teaching capacity, research output, student–staff ratios, and cost efficiency, into optimization frameworks, public managers can move beyond descriptive assessments toward prescriptive insights. Such integration enables the identification of optimal resource-allocation scenarios, explicit evaluation of trade-offs among competing objectives, and simulation of policy alternatives under different funding or demand conditions (Taiwo, 2025). This study explores how integrating OR-based optimization models into performance evaluation systems can be operationalized within Nigerian public institutions, particularly federal universities, to enhance efficiency, accountability, and evidence-based public sector management.

2. Literature Review

Public Sector Performance Evaluation in Nigeria

Performance evaluation in the Nigerian public sector has historically focused on rule compliance, financial accountability, and bureaucratic control (Adamolekun, 2002). Reforms

such as the introduction of performance budgeting and monitoring frameworks have sought to improve efficiency, but outcomes remain mixed due to weak implementation and limited analytical capacity (Olaopa, 2014). In public universities, performance evaluation often centers on accreditation outcomes, staff-student ratios, and financial audits, with little emphasis on optimizing the use of available resources (Saint et al., 2003). Scholars argue that without analytical tools to guide decision-making, performance evaluation systems fail to drive meaningful improvements in efficiency and service delivery (Ohemeng, 2010).

Optimization Models in the Public Sector

Optimization models are analytical tools designed to identify the best possible outcomes subject to explicitly defined constraints such as limited budgets, capacity restrictions, policy requirements, or service-level targets. At their core, these models formalize decision problems by specifying objective functions, such as cost minimization, output maximization, or efficiency improvement, and translating real-world limitations into mathematical constraints. Linear programming, one of the most widely used optimization techniques, has been extensively applied to problems of cost minimization, production planning, and optimal resource allocation by determining the most efficient combination of decision variables that satisfies all constraints (Hillier & Lieberman, 2021). In organizational settings, linear programming provides clear guidance on allocating scarce resources across competing activities to maximize overall performance.

Data Envelopment Analysis (DEA), on the other hand, is a non-parametric optimization-based technique used to measure the relative efficiency of comparable decision-making units (DMUs), such as universities, hospitals, or government agencies. Introduced by Charnes, Cooper, and Rhodes, DEA evaluates efficiency by simultaneously comparing multiple inputs and outputs, identifying best-practice frontiers against which underperforming units can be benchmarked (Charnes et al., 1978). Unlike traditional ratio-based performance measures, DEA accommodates the multidimensional nature of public-sector outputs, making it particularly suitable for institutions pursuing multiple objectives beyond profit maximization.

Goal programming extends conventional linear programming by allowing decision-makers to address multiple, often conflicting, objectives within a single modeling framework. Rather than optimizing a single objective, goal programming minimizes deviations from predefined targets, such as balancing cost efficiency with service coverage or equity considerations. This

flexibility makes goal programming especially relevant in public-sector contexts, where trade-offs among efficiency, accessibility, quality, and political priorities are unavoidable.

In the public sector globally, optimization techniques have been applied to a wide range of policy and planning problems, including health care resource allocation, education funding formulas, transportation and infrastructure development, and emergency service deployment. For example, optimization models have been used to determine optimal hospital bed distribution, school location planning, and maintenance scheduling for public infrastructure, demonstrating their value in improving service delivery under tight fiscal constraints (Taha, 2017). These applications highlight the potential of optimization tools to support evidence-based policymaking and enhance the efficiency of public expenditure.

Despite this potential, empirical applications of optimization models in Nigeria remain relatively limited. Most studies on public sector performance evaluation rely heavily on descriptive statistics, financial ratios, and compliance-based indicators, which describe past performance but offer little prescriptive guidance for future decision-making (Akinwale, 2014). The limited integration of optimization tools into routine planning and evaluation processes reflects constraints such as data quality issues, limited technical capacity, and weak links between analytical research and public sector management practice. Addressing these gaps would allow Nigerian public institutions to move beyond diagnostic assessments toward optimization-driven performance evaluation frameworks that actively inform resource allocation and strategic decision-making.

Integrating Performance Evaluation and Optimization

Integrating optimization models into performance evaluation frameworks enables performance indicators to move beyond their traditional descriptive role and function instead as active components of decision-support systems. In such integrated frameworks, indicators such as cost per student, student-to-staff ratios, graduation rates, service coverage, energy consumption, or budget absorption rates can be explicitly modeled as inputs, constraints, or objective functions in optimization models. For example, budget ceilings, staffing norms, and regulatory requirements can be represented as constraints. At the same time, institutional goals, such as maximizing service outputs, improving efficiency, or minimizing unit costs, can be specified as objective functions. This formalization ensures that performance metrics are directly linked to resource-allocation decisions rather than being reviewed only after decisions

have already been made (Leconte et al., 20180)

This integration fundamentally shifts performance evaluation from a passive, retrospective assessment of past outcomes to a proactive and forward-looking managerial tool. Instead of merely identifying inefficiencies or compliance gaps, optimization-based evaluation frameworks enable managers to explore "what-if" scenarios, assess trade-offs among competing objectives, and identify feasible improvement pathways under existing constraints. For instance, public-sector managers can simulate how changes in funding levels, staffing mixes, or enrollment targets would affect overall institutional performance, thereby supporting more informed and transparent decision-making (Brignall & Modell, 2000). In public institutions characterized by multiple objectives and political oversight, this approach also enhances accountability and rationality in decision processes. By making assumptions, constraints, and priorities explicit, optimization models provide a transparent basis for explaining why confident allocation choices are preferred over others. This is particularly valuable in contexts where resource allocation decisions are often contested and where managers must justify trade-offs between efficiency, equity, and service quality. Moreover, integrating optimization into performance evaluation promotes managerial learning by helping decision-makers understand the structural drivers of inefficiency and the marginal impacts of alternative policy options.

Despite these advantages, the application of optimization-integrated performance evaluation remains underexplored in the Nigerian public-sector management literature. Existing studies tend to treat performance measurement and resource allocation as separate activities, with limited analytical linkage between evaluation results and subsequent managerial actions. Where optimization models are employed, they are often used in isolation, without being embedded in formal performance management or budgeting systems. This gap highlights a missed opportunity to leverage analytical tools for improving institutional performance and public value creation. Expanding the use of optimization-based performance evaluation in Nigeria would require deliberate efforts to align performance indicators with decision models, improve data availability and quality, and build analytical capacity within public institutions (Esomonu, 2025). By embedding optimization models into routine performance evaluation processes, Nigerian public-sector organizations can transform evaluation from a compliance-driven exercise into a strategic instrument for continuous improvement, efficiency enhancement, and evidence-based governance.

3. Conceptual Framework

The proposed framework establishes a systematic link between public-sector performance evaluation and optimization-based decision-making by embedding key performance indicators directly into formal analytical models. Rather than treating performance indicators as standalone metrics reported for compliance or oversight purposes, the framework re-conceptualizes them as functional elements, inputs, constraints, and objectives, within optimization models. Core indicators such as cost efficiency, service delivery levels, capacity utilization, staff productivity, and output quality are thus transformed into actionable variables that actively shape resource-allocation decisions (John, 2023).

In the context of Nigerian universities, this framework is particularly relevant given chronic funding constraints, increasing student enrolment, and persistent pressures to improve teaching and research outcomes. Data routinely generated within university systems, such as academic and non-academic staff workloads, student enrolment by faculty or department, class sizes, graduation rates, and recurrent operating costs, can be systematically incorporated into linear programming or related optimization models. For instance, departmental budget allocations can be modeled as decision variables, while total available funding represents a binding budget constraint. Regulatory requirements on minimum staffing levels, accreditation standards, and quality assurance benchmarks can be incorporated as additional constraints, ensuring that optimization outcomes remain policy-compliant (O'Gorman, Partington, Potrac, & Nelson, 2021).

Within this framework, performance indicators derived from existing evaluation systems serve dual roles. First, they define the objectives of the optimization model, such as minimizing cost per student, maximizing teaching capacity utilization, or improving the balance between instructional and research activities. Second, they function as constraints that reflect institutional realities and policy limits, such as maximum allowable student-staff ratios, limits on teaching loads, or caps on recurrent expenditure growth. By explicitly modeling these indicators, the framework ensures that optimization results are grounded in empirically observed performance data rather than abstract assumptions (Fernández-Miguel et al., 2026).

Once specified, the optimization model generates feasible and optimal solutions that identify how limited resources should be distributed across departments or programs to achieve the best possible overall performance. These solutions provide managers with clear, quantitative guidance on trade-offs, for example, how reallocating funds from low-utilization units to high-demand programs could improve aggregate efficiency without compromising quality

standards. Importantly, the model can also be used for scenario analysis, allowing university administrators to examine the performance implications of alternative policy choices, such as changes in enrolment targets, staffing structures, or funding levels.

By linking performance evaluation to optimization in this manner, the proposed framework transforms evaluation from a static reporting exercise into a dynamic planning and decision-support tool. It enables Nigerian public universities to align resource allocation with strategic objectives, improve transparency and accountability in budgeting decisions, and systematically pursue efficiency gains while respecting budgetary, regulatory, and quality constraints. Ultimately, the framework provides a practical pathway for integrating analytical rigor into public sector performance management and institutional governance (Nwafor et al., 2019).

4. Methodological Approach

This study adopts a conceptual and analytical methodology grounded in a review of the existing literature and illustrative examples from Nigerian public institutions. The approach is designed to demonstrate how optimization models can be integrated into public sector performance evaluation rather than to generate new empirical estimates.

Linear programming is emphasized as a cost-minimization and resource allocation tool suited to environments characterized by limited budgets and competing demands. Illustrative applications show how data on enrolment, staff workload, and operating costs can be incorporated into linear programming models to guide efficient allocation of resources within public institutions.

In addition, data envelopment analysis (DEA) is discussed as a benchmarking technique for assessing relative efficiency across comparable institutions. Using examples such as the University of Ibadan and the Obafemi Awolowo University, DEA is presented as a diagnostic tool for identifying efficiency gaps and best practices. Together, these methods provide a concise analytical basis for performance evaluation driven by optimization in Nigerian public institutions.

5. Discussion

The integration of optimization models into performance evaluation systems has important implications for Nigerian public institutions, particularly in shifting evaluation from diagnosis

to prescription. Rather than merely identifying inefficiencies after the fact, optimization-based evaluation enables managers to determine optimal courses of action within existing constraints. In federal universities, for instance, optimization models can inform decisions on staff deployment, course scheduling, space utilization, and budget allocation, thereby improving teaching quality, balancing workloads, and reducing operational waste. This prescriptive orientation strengthens managerial decision-making and links performance evaluation directly to institutional improvement (Chanca-Mucha et al., 2026).

A second implication relates to transparency and accountability in public resource management. Optimization-enhanced evaluation frameworks require explicit specification of objectives, constraints, and decision rules. By formalizing these elements, such models reduce the scope for discretionary and ad hoc allocation decisions, which political and administrative pressures have historically influenced in Nigerian public administration. As noted by Adamolekun (2002), weak institutional controls and politicization of administrative processes have undermined efficiency in the public sector. Optimization models help address this challenge by providing a rational and transparent basis for allocation decisions that oversight bodies and stakeholders can scrutinize.

Third, the use of optimization models facilitates scenario and sensitivity analysis, allowing institutions to anticipate how changes in key parameters affect performance outcomes. Public institutions in Nigeria frequently face budget volatility, delayed releases, and unplanned enrolment growth. Through scenario analysis, managers can assess the performance implications of funding cuts, enrolment expansion, or policy changes before they occur, and design mitigation strategies accordingly. This forward-looking capability enhances institutional resilience and supports more adaptive planning.

Despite these advantages, implementing optimization-integrated performance evaluation effectively faces practical challenges (Shan et al., 2025). Reliable and timely data are essential for model accuracy, yet data systems in many Nigerian public organizations remain weak and fragmented. In addition, limited technical capacity and insufficient familiarity with optimization tools constrain their routine use in management processes. Addressing these constraints through improved data infrastructure, capacity building, and institutional support is critical if the full benefits of performance evaluation enhanced by optimization are to be realized in the Nigerian public sector.

6. Conclusion

This study demonstrates that the integration of optimization models into public sector performance evaluation has strong potential to enhance efficiency, accountability, and strategic decision-making in Nigerian public institutions. By embedding Operations Research (OR) techniques into performance evaluation frameworks, public managers are better equipped to move beyond compliance-oriented assessments toward evidence-based, solution-focused management. Optimization models provide a structured means of linking performance indicators directly to resource-allocation decisions, thereby addressing the persistent challenge of achieving improved outcomes under fiscal constraints.

The study shows that optimization-based evaluation frameworks can transform performance assessment from a retrospective reporting exercise into a proactive management tool that supports planning, prioritization, and institutional learning. Through techniques such as linear programming and efficiency benchmarking, managers can identify optimal allocation strategies, evaluate trade-offs among competing objectives, and anticipate the performance implications of alternative policy choices. This approach strengthens transparency and accountability by making objectives, constraints, and decision rules explicit, thereby improving the rationality of public-sector decision-making.

By situating optimization-based performance evaluation within the context of a developing economy, this study contributes to the public sector management literature in two important ways. First, it extends existing discussions on performance evaluation by demonstrating how analytical and prescriptive tools can be adapted to environments characterized by limited resources, data constraints, and institutional weaknesses. Second, it provides a context-specific framework for Nigerian public institutions, particularly in the higher education sector, highlighting practical pathways for integrating OR techniques into existing evaluation and management systems.

Generally, the study underscores the need for Nigerian public institutions to strengthen data systems, build analytical capacity, and institutionalize the use of optimization tools within performance management processes. Such reforms would not only improve operational efficiency but also enhance public trust and value creation, positioning performance evaluation as a central instrument for sustainable public sector governance and development.

7. Recommendations

Public institutions in Nigeria should adopt a gradual, structured approach to integrating optimization models into their performance evaluation systems to improve resource utilization, service delivery, and overall institutional efficiency. Rather than viewing optimization as a stand-alone technical exercise, it should be embedded within existing performance management and budgeting frameworks. This phased integration allows institutions to align analytical tools with administrative realities, data availability, and regulatory requirements, thereby increasing the likelihood of successful adoption.

Federal universities, in particular, should prioritize the use of linear programming and data envelopment analysis (DEA) to support core managerial decisions. Linear programming can be applied to guide budget allocation across faculties and departments, optimize staff deployment, balance teaching loads, and improve capacity utilization of classrooms, laboratories, and other facilities. DEA can complement these efforts by benchmarking departments or institutions against best-performing peers, identifying sources of inefficiency, and providing evidence-based targets for performance improvement. Together, these tools can help university administrators justify allocation decisions transparently while improving academic and operational outcomes.

At the system-wide level, government agencies and oversight bodies should invest in strengthening data infrastructure and analytical capacity. Reliable, timely, and standardized data are essential for effective optimization-based decision-making. This requires improvements in management information systems, harmonization of reporting standards, and routine collection of performance-relevant data. In parallel, analytical capacity building, through recruitment of skilled analysts, continuous professional development, and collaboration with academic institutions, should be prioritized to ensure that optimization models are properly designed, interpreted, and applied.

Policymakers also have a critical role to play by explicitly incorporating optimization tools into public sector reform initiatives. Performance evaluation frameworks should be designed to feed directly into planning, budgeting, and policy formulation processes, ensuring that evaluation results inform real decisions rather than serving purely compliance or audit functions. Clear policy guidance on the use of analytical tools can help institutionalize optimization-driven decision-making and reduce resistance to change.

Finally, to ensure long-term sustainability, training programs in Operations Research, public sector analytics, and quantitative decision-making should be institutionalized within the public service. Embedding these competencies in civil service training institutions and higher education curricula will build a pipeline of professionals capable of sustaining optimization-based performance management over time. Collectively, these measures can position optimization models as integral components of public sector governance, supporting more efficient, accountable, and strategic management of public resources in Nigeria.

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