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An Analytics-Enabled Framework for Intelligent Procurement and Inventory Management in Government Agencies

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RESEARCH ARTICLE INFORMATION	ABSTRACT

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Transparency, efficiency, and regulatory compliance are essential to effective government resource management. Despite the adoption of digital procurement and inventory systems, many public-sector agencies continue to encounter challenges such as fragmented data, limited inventory visibility, delayed processes, and insufficient decision-support capabilities. These issues can hinder timely planning and efficient utilization of public resources. This study aimed to develop and evaluate an analytics-enabled framework for intelligent procurement and inventory management to support data-driven decision-making in government operations. A design-oriented research approach was employed, incorporating process analysis, framework modeling, prototype development, and simulation-based evaluation. Historical procurement and inventory records were utilized to support diagnostic and predictive analytics, enabling the identification of process bottlenecks, demand forecasting, and analysis of equipment lifecycle patterns. The developed framework integrates operational modules, analytics pipelines, forecasting components, and decision-support dashboards within a unified architecture. Prototype simulation and forecasting evaluation demonstrated the capability of the framework to generate analytical insights that support procurement planning, inventory monitoring, and asset management. In addition, expert validation indicated that the proposed framework is practical and aligned with operational requirements commonly observed in government agencies. In general, the framework demonstrates the potential of analytics-enabled process integration to enhance transparency, accountability, and resource management. Future studies may focus on validating the framework in actual operational environments, extending analytical capabilities, and integrating the framework with existing government information systems.

Keywords: *procurement and inventory management, government resource management, business process reengineering, predictive analytics, decision support, forecasting*

Introduction

Government agencies operate in environments where transparency, efficiency, and accountability are fundamental to the effective management of public resources. Procurement and inventory management are essential functions that ensure supplies, equipment, and services which are acquired, monitored, and utilized in accordance with established regulations and organizational objectives. Despite continuing efforts toward digital transformation, many public institutions still experience lengthy procurement cycles, fragmented information systems, reliance on manual documentation, and limited visibility into operational data. These challenges constrain timely decision-making and affect overall organizational performance. Guendez et al. (2025) emphasized that rigid administrative structures often hinder innovation in public-sector operations. Likewise, Thai (2019) highlighted that effective procurement systems require integration, transparency, and accountability throughout the procurement lifecycle. The Organization for Economic Co-operation and Development (OECD, 2025) further stressed that digital transformation is essential for strengthening transparency, performance monitoring, and public value creation.

Addressing these issues requires more than simply automating existing procedures. Business Process Reengineering (BPR) provides a process-oriented perspective that focuses on the fundamental analysis and redesign of organizational workflows to achieve significant improvements in performance. Hammer and Champy (1993) argued that organizations should rethink existing processes rather than merely computerize inefficient procedures. Similarly, Davenport (1993) emphasized that information technologies should serve as enablers of redesigned processes rather than isolated tools. Van der Aalst (2019) further noted that process-oriented approaches supported by data and analytics enable organizations to identify bottlenecks, eliminate redundancies, and improve operational responsiveness. In this context, analytics should not be viewed as standalone technologies but as integral components that support process transformation and evidence-based decision-making.

Recent studies have demonstrated the growing role of analytics and intelligent technologies in improving public-sector operations. Andersson et al. (2025) reported that artificial intelligence applications can enhance forecasting and operational efficiency when supported by reliable and integrated data infrastructures. Cocciolo et al. (2023) observed that inconsistent workflows and siloed data environments reduce the effectiveness of digital procurement initiatives. Karttunen et al. (2022) identified legacy systems as a major barrier to analytics-driven transformation, while Kundu et al. (2025) argued that the absence of predictive capabilities limits the ability of government agencies to optimize procurement activities and maintain inventory visibility. Furthermore, Wamba et al. (2017) emphasized that data analytics can significantly improve organizational performance when embedded within business processes rather than implemented as separate technological components.

In the context of procurement analytics in the public sector, the digitization of procurement in the public sector has accelerated in recent years. For instance, the study of public procurement data analytics by Cocciolo et al. (2023) demonstrated how governments can monitor procurement trends, compare performance across agencies, and support oversight bodies. Meanwhile, Karttunen (2022) explored how public procurement acts as an "attractive customer" and how supply-chain ambidexterity strategies are applied by suppliers in government contracting, emphasizing how analytics can aid supplier selection and performance monitoring. Further, Andersson et al. (2025) assessed the value of artificial intelligence in public procurement, covering effects on public value, transparency, and process efficiency. However, although the literature highlights the potential of analytics and AI, it also emphasizes the gap in fully integrated procurement platforms in government agencies that include forecasting, alerts, and dashboarding as part of routine operations. For instance, Mokeeva & Yurko (2022) studied how digital tools can detect suspicious purchases in government procurement, but often these tools remain siloed rather than part of a broader system.

Additionally, in terms of inventory management and forecasting, inventory control in government agencies is less frequently studied than private-sector applications, yet the need is just as acute. Research by Goltsos et al. (2022) highlighted the gap between demand forecasting and inventory control in supply chains, which applies directly to government stock items and equipment. A more recent work by Harahap et al. (2025) explores how demand forecasting techniques (exponential smoothing, regression models, bootstrapping) help optimize inventory levels, reduce stock-outs, and improve resource allocation. Further, Alam et al. (2023) studied inventory management systems in small and medium enterprises but highlighted implications for government and public sector organizations in terms of data integration and digital capabilities. The literature thus underscores that forecasting and analytics are central to inventory efficacy, yet practical frameworks tailored for the government context remain scarce.

Essentially, the concept of "intelligent" procurement and inventory systems in the parlance of intelligent systems and analytics integration implies the embedding of analytics (predictive, diagnostic) and automation within core workflows rather than as separate modules. Stütz et al. (2023) presented a next-generation procurement workspace for private sector organizations that integrates information, automation, and analytics. Moreover, Mishra et al. (2024) proposed a data-mesh architecture for public procurement and infrastructure decision-making, emphasizing the value of combining knowledge graphs, AI agents, and analytics for government resource management. These studies showed the trend towards integrated systems, yet they also revealed that many government agencies remain on legacy platforms and struggle to adopt end-to-end analytics frameworks. The existing literature, therefore, suggests a gap: dedicated frameworks that unite procurement process design, inventory forecasting, analytic pipelines, and real-time dashboards in the public-sector context.

Furthermore, predictive models for procurement demand forecasting is an essential component of intelligent procurement systems, particularly in government settings where purchasing cycles, budget calendars, and seasonal usage patterns strongly influence resource flows. Prophet is highly relevant to this framework because it is designed to capture complex seasonality, holiday effects, and irregular demand trends, making it suitable for procurement environments that experience fiscal-year spikes, policy-driven purchasing surges, and periodic supply requests. Studies have highlighted Prophet's capacity to model both short-term fluctuations and long-term seasonal patterns even with incomplete or noisy datasets, which is often the case in government procurement records (Smith, 2021).

Meanwhile, ARIMA remains a strong choice for modeling linear and time-dependent patterns in procurement demand because of its proven stability, interpretability, and effectiveness in datasets with consistent historical trends. ARIMA has been widely applied to forecasting problems where understanding autocorrelation and temporal dependencies is crucial for decision-making accuracy (Kumar, 2022). Compared to more complex machine learning approaches, such as LSTM, Random Forest Regression, or SVM, which require larger datasets, higher computational resources, and more intensive parameter tuning, Prophet and ARIMA provide a pragmatic, efficient, and reliable forecasting foundation for government systems where data volume may be limited, and transparency of forecasting logic is essential for auditability. Their combined strengths align well with the characteristics of procurement data, ensuring forecasts that are both robust and interpretable, supporting improved planning, reduced stockouts, and more efficient budget utilization.

Effective resource management in government is not just about systems and analytics; it also involves governance, compliance, and transparency. For example, Guenduez et al. (2025) emphasized how procurement can be a procedural tool for innovation within government agencies and how the digital transformation of public procurement serves broader public-value aims. The OECD's 2025 report on the digital transformation of public procurement further highlights how integrating systems across agencies (including procurement and inventory) supports the capture of value for money and improved reporting. Despite these positive signals, many frameworks for public-sector resource management focus primarily on procurement or inventory in isolation. Few address the full lifecycle from user authentication through operational modules, analytics pipelines, forecasting, and dashboards. Thus, the research gap lies in designing a comprehensive, unified framework for intelligent procurement and inventory management specifically tailored for government resource management.

Although previous studies have recognized the benefits of digital technologies, forecasting models, and analytics, many investigations focus primarily on automation, demand forecasting, or information systems as separate solutions. Comparatively fewer studies examined procurement and inventory management from a business process reengineering perspective, where workflows are fundamentally redesigned, and analytics are embedded directly into operational processes. Existing frameworks frequently treat analytical capabilities as supplementary features instead of integral elements of process transformation. Consequently, there remains a need for a unified framework that combines process redesign, predictive analytics, and decision-support capabilities within a single architecture for government resource management. Similar observations were reported by the World Bank (2021), OECD (2025), and Guenduez et al. (2025), all of whom emphasized the importance of integrating digital technologies with organizational processes to support effective public-sector governance.

In response to this gap, the present study aimed to develop an analytics-enabled framework for intelligent procurement and inventory management in government agencies. Anchored in business process reengineering principles, the study focused on examining existing ("as-is") workflows and designing improved ("to-be") processes supported by predictive and diagnostic analytics. Specifically, the study analyzed the current procurement and inventory processes, developed a framework that integrates operational modules with analytics and decision-support components, and demonstrated how analytics-enabled process integration can support transparency, operational efficiency, and evidence-based decision-making. The study contributes a layered framework that aligns process reengineering, analytics, and system architecture, thereby providing a reference model for improving government resource management.

Methods

This study adopted a Business Process Reengineering (BPR)-oriented, design-oriented research approach to systematically analyze and redesign procurement, inventory, and equipment management processes in government agencies. The study followed the BPR lifecycle, consisting of process discovery, process diagnosis, process redesign, technology enablement, and validation. Through this approach, the proposed framework was developed as a process-centered artifact that integrates operational workflows with analytics and decision-support mechanisms.

Consistent with BPR principles, the study began with an examination of existing ("as-is") workflows to understand how procurement and inventory activities were being performed, how information flowed across organizational units, and where delays, redundancies, and inefficiencies occurred. Findings from this stage served as the basis for designing improved ("to-be") processes. Digital technologies and analytics were treated as enablers of process transformation and were embedded directly into redesigned workflows rather than implemented as independent system features. The overall research process involved process mapping, gap analysis, framework development, prototype simulation, and forecasting evaluation.

Locale of the Study

The study was conducted within the operational context of the target government agency responsible for procurement, inventory management, and equipment lifecycle monitoring. The workflows, datasets, and operational scenarios examined in the study reflected the actual practices and requirements of the agency. This approach ensured that the proposed framework was grounded in the organization's operational environment while remaining potentially adaptable to other government institutions with similar regulatory and operational characteristics.

Participants and Respondents

The study involved selected personnel from the target government agency responsible for procurement, inventory management, and property accountability. Participants were purposively selected based on their direct involvement in procurement and inventory operations and their familiarity with existing policies, procedures, and operational requirements. These participants included procurement officers, inventory managers, and equipment custodians whose operational insights contributed to process analysis and framework development.

Their inputs and observations were utilized to ensure that the proposed analytics-enabled framework reflected the operational requirements and workflow characteristics of the agency.

Research Instruments

Several research instruments were employed to support process reengineering and framework development. These included as-is and to-be process maps, a layered conceptual framework, system architecture diagrams, forecasting models, and analytics dashboards. The forecasting component incorporated time-series forecasting models to support demand analysis and equipment lifecycle assessment. Simulation performance indicators and analytical outputs were used to examine the functionality of the framework and demonstrate how analytics-enabled processes can support decision-making within procurement and inventory operations.

Data Collection Procedure

Data collection followed the BPR principle of understanding existing operations before redesign. Existing procurement, inventory, and equipment management processes were first documented as as-is workflows. These processes included purchase request creation, purchase order issuance, supplier management, receiving and issuing of supplies, stock transfers and returns, equipment assignment, usage logging, maintenance scheduling, and retrieval activities.

In order to support forecasting evaluation and prototype simulation, historical transaction records covering the period from 2019 to 2025 were obtained from the agency database. A total of 6,972 procurement and inventory transaction records were collected. The dataset included transaction dates, item descriptions, quantities issued, monthly demand totals, inventory movement records, and equipment usage and maintenance information.

Prior to analysis, the collected data underwent preprocessing procedures that included data validation, duplicate removal, correction of inconsistent records, handling of missing values, aggregation of transactions into monthly demand totals, and feature engineering. To ensure confidentiality and compliance with ethical standards, sensitive information and personally identifiable data were removed or anonymized before analysis.

In addition, literature-based best practices and analytics-enabled process models were reviewed and used as references during gap identification. This comparison enabled the researcher to identify process steps that could be simplified, automated, or enhanced through analytics during the redesign stage.

Data Analysis

Data analysis combined process-level Business Process Reengineering (BPR) analysis and forecasting evaluation. From a process perspective, inefficiencies, bottlenecks, and redundant activities were identified by comparing existing workflows with best-practice, analytics-enabled processes. The findings from this analysis guided the design of the reengineered workflows embedded within the proposed framework.

From an analytics perspective, preprocessing activities included data validation, cleaning, aggregation, and feature engineering to prepare the datasets for forecasting and diagnostic analysis. Forecasting outputs were evaluated using statistical error measures, namely Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Scaled Error (MASE). Historical records were divided into training and validation periods, and walk-forward validation was employed to simulate actual forecasting conditions.

Simulation outputs, dashboards, and analytical indicators were examined to demonstrate the capability of the framework to provide inventory visibility, support workflow monitoring, and generate decision-support information for procurement and inventory management. The combined results of process analysis, forecasting evaluation, and prototype simulation were used to assess the functionality and applicability of the proposed analytics-enabled framework within the operational context of the target government agency.

Framework Development and Prototype Simulation

Based on the results of the BPR analysis and analytics integration, a layered intelligent procurement and inventory framework was developed. The framework consists of five interconnected layers: (1) Login and Authentication, (2) Operational Modules, (3) Data Preprocessing and Analytics Pipeline, (4) Predictive Forecasting, and (5) Decision-Support Outputs.

A prototype implementation was developed to simulate end-to-end data flow across reengineered processes, demonstrating how transactional data from operational modules feeds into the analytics pipeline and generates analytical insights that may assist decision-makers. The simulation illustrated how analytics-driven outputs, such as demand forecasts, depletion alerts, and dashboards, are embedded directly into redesigned workflows to support proactive procurement and inventory management.

Ethical Considerations

Ethical standards were observed throughout the conduct of the study. Historical procurement and inventory records obtained from the agency database were used solely for research purposes and underwent anonymization to prevent the disclosure of sensitive or personally identifiable information. Data preprocessing procedures included the removal of identifiers and the treatment of confidential information to ensure compliance with data privacy and institutional policies.

Prototype simulation and forecasting evaluation were conducted using anonymized operational datasets and simulated scenarios derived from actual workflows. Prototype simulation and forecasting evaluation were conducted using anonymized operational datasets and simulated scenarios derived from actual workflows. Throughout the study, principles of confidentiality, objectivity, and responsible data handling were maintained in accordance with institutional research ethics guidelines.

Results and Discussion

This section presents the results of the study in relation to the stated objectives, with particular emphasis on the development and evaluation of the proposed intelligent procurement and inventory framework, illustrated in Figure 1. The results highlight how the framework was constructed, how its analytics components performed, and how it supports decision-making in government operations.

Development of the Intelligent Procurement and Inventory Framework

The primary outcome of the study is the development of a layered framework that integrates procurement, inventory, and equipment management with analytics and decision-support capabilities. As shown in Figure 1, the framework brings together security, operational workflows, data processing, forecasting, and visualization into a single, coherent structure.

At the entry point of the framework, the Login and Authentication Layer provides secure access through user credential input, HRMIS verification, role mapping, and token generation. This layer ensures that only authorized users can access specific system functions, supporting accountability and role-based control across government units. On the other hand, the Operational Modules Layer reengineers core government workflows into three closely connected modules: procurement, inventory, and project equipment. These modules cover essential activities such as purchase request creation, purchase order issuance, supplier and delivery management, receiving and issuing of supplies, stock transfers and returns, and equipment assignment, usage logging, maintenance, and retrieval. Integrating these processes into a single framework addresses the fragmentation and workflow interruptions observed during the analysis of existing practices.

Supporting these operational modules is the Data Preprocessing and Analytics Pipeline, which prepares raw transactional and usage data for analysis. This pipeline performs validation, cleaning, aggregation, and feature engineering to ensure that data used for forecasting and diagnostics are accurate and reliable. The Predictive Demand Forecasting Layer incorporates time-series forecasting models to support demand analysis and inventory monitoring. Using historical procurement and inventory records, this layer generates demand forecasts, estimates expected stock depletion timelines, and analyzes consumption trends over time.

Finally, the Outputs Layer delivers practical decision-support tools, including item-level demand forecasts, low-stock and imminent depletion alerts, and dashboards that display forecast trends, stock status, and procurement performance indicators. Together, these components illustrate the achievement of the study's main objective: the development of a framework that integrates process redesign and analytics to support data-driven government resource management.

Forecasting Performance of the Analytics Component

The forecasting component of the framework was evaluated using historical procurement and inventory records through a simulation-based assessment. Statistical error measures, including Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Scaled Error (MASE), were utilized to examine the predictive capability of the implemented forecasting models. In addition to generating demand forecasts, the analytics component produced depletion timelines and consumption trends that may support procurement planning and inventory monitoring. These outputs indicate how forecasting functionality can be integrated into reengineered workflows to provide analytical support for operational decision-making and facilitate more proactive resource management.

Enhanced Visibility and Decision Support

The dashboard and alert features of the framework provide visibility into procurement and inventory operations. Through dashboard visualizations, users can monitor stock conditions, procurement cycle performance, supplier lead-time variations, and projected equipment lifespans. Alerts for low stock levels and expected depletion support timely interventions and encourage more proactive decision-making. These results indicate that the framework extends beyond the generation of analytical outputs by transforming operational data into accessible information that can support the needs of government managers. These findings also support the view that analytics derive greater value when integrated within organizational processes rather than implemented as isolated technologies. Davenport (1993) emphasized that information technologies should enable redesigned processes, while van der Aalst (2019) highlighted the importance of process-oriented analytics in improving visibility and supporting operational decision-making. In the context of the present study, the integration of forecasting, diagnostics, and dashboard visualization within reengineered workflows illustrates how analytical capabilities can complement business process reengineering initiatives in government organizations.

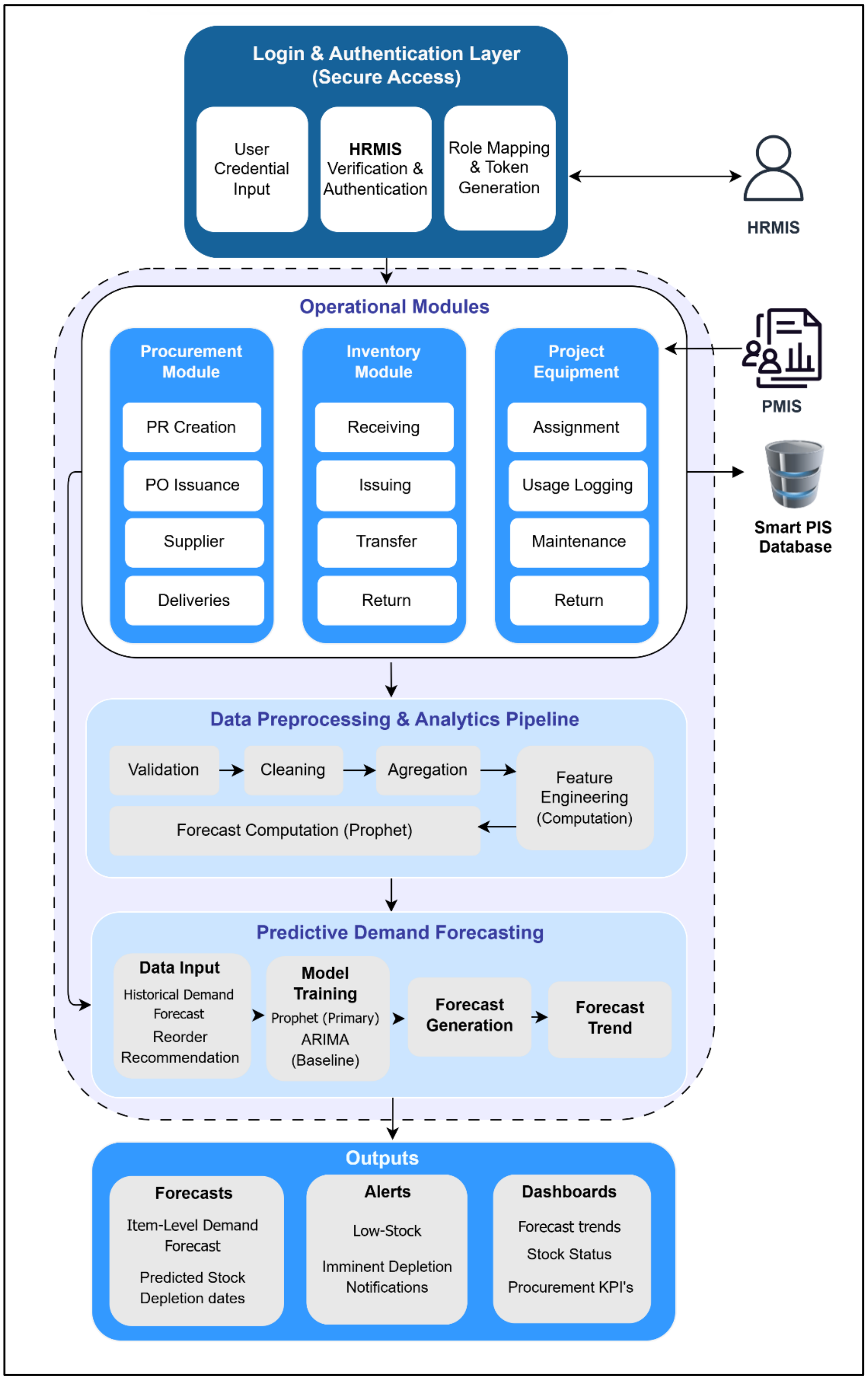

Figure 1. *Conceptual Framework of the Intelligent Procurement and Inventory System with Analytics*

As illustrated in Figure 1, the framework integrates operational processes, analytics components, and decision-support mechanisms within a unified architecture to support process improvement and evidence-based decision-making, consistent with the process-oriented perspective of Davenport (1993). This integration reflects the Business Process Reengineering principle of embedding information technologies into redesigned workflows to support process improvement and evidence-based decision-making.

The results suggest that predictive analytics can serve as an enabling mechanism within reengineered procurement and inventory processes. Rather than functioning as isolated analytical tools, forecasting and diagnostic components were embedded directly into redesigned workflows, allowing operational data to be transformed into decision-support information. This process-oriented integration is consistent with the principles of Business Process Reengineering proposed by Hammer and Champy (1993), which emphasized the redesign of core processes to achieve improved organizational performance.

The framework also illustrates the importance of integrating analytics with operational systems. Cocciolo et al. (2023) observed that fragmented workflows and siloed data environments reduce the effectiveness of digital procurement initiatives, while Karttunen et al. (2022) identified legacy systems as barriers to analytics-driven transformation. By integrating procurement, inventory, and equipment management functions within a unified architecture, the proposed framework addresses these challenges and supports greater visibility across operational processes.

The forecasting component was evaluated using historical records and statistical error measures. Simulation-based assessment indicated the capability of the framework to generate demand forecasts, depletion timelines, and consumption trends that may support procurement planning and inventory monitoring. These observations were derived from prototype simulation and historical data analysis and therefore represent the potential application of analytics-enabled workflows within government procurement and inventory operations.

These findings are consistent with the observations of Andersson et al. (2025), who emphasized that analytics and intelligent technologies can strengthen operational decision-making when supported by reliable and integrated data infrastructures. Similarly, Kundu et al. (2025) argued that predictive capabilities are essential for improving inventory visibility and supporting proactive resource management.

From a practical perspective, the framework illustrates how analytics-enabled process integration can support transparency, accountability, and evidence-based decision-making in government agencies. More importantly, the findings highlight the role of analytics as an enabling mechanism for business process reengineering by embedding forecasting and decision-support capabilities directly into redesigned workflows. The availability of dashboards, analytical indicators, and forecasting outputs may assist managers in monitoring stock conditions, identifying potential bottlenecks, and planning procurement activities more effectively. However, the successful implementation of the framework depends on the availability of reliable historical data, organizational readiness, and the capability of agencies to integrate data across existing systems. In addition, staff training and change management remain important considerations for the adoption of analytics-driven processes in public-sector environments. These implementation considerations are consistent with the observations of Guenduez et al. (2025) and the OECD (2025), who emphasized that organizational readiness, workforce capabilities, and institutional support are critical factors influencing the successful adoption of digital transformation initiatives in the public sector.

Conclusion and Future Works

This study developed an analytics-enabled framework for intelligent procurement and inventory management to support business process reengineering initiatives in government agencies. Anchored on process redesign principles, the framework integrates procurement, inventory, and equipment management workflows with analytics and decision-support mechanisms within a unified architecture. By embedding forecasting and diagnostic capabilities directly into redesigned processes, the framework illustrates how analytics can function as enabling mechanisms for process transformation rather than as isolated technological components.

Results derived from historical data analysis and prototype simulation indicate the capability of the framework to generate demand forecasts, depletion timelines, analytical indicators, and dashboard-based visualizations that may support procurement planning, inventory monitoring, and evidence-based decision-making. The study further highlights the importance of integrating analytics within reengineered workflows to improve process visibility and strengthen decision-support capabilities. As a process-oriented framework, the proposed architecture provides a reference model for government agencies seeking to modernize resource management practices while promoting transparency, accountability, and operational efficiency.

Despite these contributions, the study is limited to framework development, historical data analysis, and prototype simulation within the operational context of government procurement and inventory management. Consequently, the findings represent the potential application of analytics-enabled workflows and do not constitute evidence of full-scale operational implementation.

Future studies may focus on validating the framework in actual government environments and extending its application across multiple agencies. Additional research may explore the integration of machine learning and hybrid forecasting approaches to address more complex demand patterns and improve analytical capabilities. Future developments may also incorporate prescriptive analytics to support procurement recommendations, replenishment strategies, and supplier evaluation. Furthermore, investigations into organizational readiness, user adoption, change management, and interoperability with existing government enterprise systems may contribute to the long-term sustainability and scalability of analytics-enabled process transformation initiatives.

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Conflict of Interest

The authors declare that there are no personal, institutional, financial, or non-financial conflicts of interest that could have influenced the conduct, analysis, or reporting of this research. No external organizations or commercial entities were involved in shaping the research objectives, methodology, data analysis, or interpretation of findings. Any institutional resources or support provided were used solely for academic and research purposes, and appropriate measures were observed to ensure objectivity, transparency, and academic integrity throughout the study.

Artificial Intelligence (AI) Declaration Statement

During the preparation of this manuscript, the authors utilized artificial intelligence (AI) tools to support specific stages of the research and writing process. In particular, OpenAI's ChatGPT (GPT-4.5) was used for language refinement, grammar correction, and the generation of preliminary drafts for selected sections of the literature review and discussion. Additionally, Zotero's AI-powered citation assistant was employed to assist in identifying and organizing relevant academic references.

These AI tools were used strictly as supportive aids to enhance clarity, coherence, and efficiency. No AI-generated content was incorporated without thorough human review. All outputs were carefully evaluated by the authors to ensure accuracy, relevance, and alignment with the objectives of the study. All substantive intellectual contributions, including the research design, data analysis, interpretation of findings, and conclusions, were entirely produced by the authors. To uphold academic integrity, AI-assisted outputs were cross-verified against primary sources, and all content was manually edited to reflect the authors' intended meaning, scholarly tone, and academic standards.

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