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## Building econometric models for evaluating cost efficiency in healthcare procurement systems

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### Abstract

The efficient procurement of healthcare resources is vital for maintaining sustainable and equitable healthcare systems. This paper explores the application of econometric models in evaluating and enhancing cost efficiency in healthcare procurement processes. It provides a theoretical overview of econometric modeling, emphasizing its relevance in addressing procurement challenges such as budget constraints, supplier variability, and market dynamics. A structured framework is proposed, outlining steps for data integration, model development, and decision-making alignment to optimize resource allocation. Additionally, the paper identifies key variables, such as supplier performance and demand trends, that drive cost efficiency. While challenges like data quality and modeling complexities persist, advances in data analytics and artificial intelligence offer significant opportunities for innovation. The recommendations include policy-level interventions, capacity-building initiatives, and practical strategies for stakeholders to improve procurement practices and drive financial sustainability in healthcare systems.

**Keywords:** Econometric Models; Healthcare Procurement; Cost Efficiency; Data Analytics; Resource Optimization; Artificial Intelligence

### 1. Introduction

Healthcare procurement systems play a pivotal role in ensuring the delivery of essential medical supplies, equipment, and services to healthcare institutions (Moons, Waeyenbergh, & Pintelon, 2019). These systems are tasked with acquiring high-quality resources at optimal costs, a responsibility that becomes increasingly complex in the face of rising healthcare demands, budgetary constraints, and fluctuating market conditions. In many healthcare systems worldwide, procurement inefficiencies result in significant financial losses, reduced operational efficiency, and compromised patient care. Addressing these inefficiencies requires a data-driven approach that balances cost management with quality assurance (Omar et al., 2021).

Econometric models offer a promising avenue for tackling such challenges. These models provide valuable insights into cost drivers and inefficiencies within procurement systems by leveraging statistical and mathematical methods to analyze economic data (Alhabatah, Yaqot, Menezes, & Kerbache, 2023). Through predictive analysis and performance evaluations, econometric models can guide healthcare administrators in making informed, evidence-based decisions. As healthcare systems increasingly integrate digital tools and data analytics, the application of econometrics emerges

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as a critical strategy for optimizing procurement operations and enhancing financial sustainability (Hallikas, Immonen, & Brax, 2021).

The primary objective of this exploration is to assess the theoretical underpinnings of econometric models and their utility in evaluating cost efficiency in healthcare procurement systems. This paper examines how these models can be conceptualized and tailored to address the unique complexities of healthcare procurement. Specifically, it will explore the types of econometric models most suitable for such evaluations, identify the key variables and metrics that inform these models, and propose a conceptual framework for their implementation.

Another core goal is to shed light on the potential impact of adopting econometric models on decision-making processes within healthcare organizations. By understanding the relationships between procurement costs, supplier performance, and market dynamics, healthcare stakeholders can develop more strategic approaches to purchasing (Kuziemski & Misuraca, 2020). This includes negotiating better contracts, streamlining supply chains, and identifying opportunities for cost reduction without compromising service quality. Furthermore, the paper aims to identify potential challenges in deploying econometric models, such as data availability, technical expertise, and organizational readiness. These challenges underscore the need for a comprehensive approach combining technical, financial, and managerial considerations to implement econometric solutions.

Improving cost efficiency in healthcare procurement systems has far-reaching implications for all stakeholders involved. For healthcare providers, cost savings from more efficient procurement can be redirected toward patient care, infrastructure development, and workforce expansion. In resource-constrained settings, such savings can mean the difference between delivering adequate care and facing service disruptions (Mulligan & Bamberger, 2019).

Econometric models offer policymakers and administrators a robust tool for monitoring and improving procurement processes. By providing a clear picture of spending patterns and identifying areas of inefficiency, these models can help design policies that promote transparency, accountability, and value for money. In addition, adopting such data-driven approaches aligns with global trends toward evidence-based policy-making and the digitization of healthcare systems (Fazekas & Blum, 2021).

Patients stand to benefit significantly from improved procurement efficiency. Streamlined processes can lead to more reliable availability of medications and medical supplies, reduced costs of services, and overall enhancements in care quality. By ensuring that procurement systems function optimally, healthcare institutions can better meet the needs of their patients while maintaining financial stability (Boulding & Hinrichs-Krapels, 2021). In the broader context, econometric modeling supports the sustainability of healthcare systems. Rising healthcare costs are a global concern, and addressing inefficiencies in procurement is a critical component of cost containment strategies. By integrating econometric analysis into procurement practices, healthcare organizations can build more resilient systems capable of adapting to economic pressures and evolving healthcare needs.

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## 2. Theoretical Framework

### 2.1. Overview of Econometric Models

Econometric models combine statistical techniques and economic theories to analyze relationships within economic data. These models serve as powerful tools for understanding cost drivers, forecasting trends, and evaluating the efficiency of resource allocation. At their core, econometric models aim to quantify the relationships between variables, providing empirical evidence that guides decision-making processes.

There are several types of econometric models relevant to cost analysis. Linear regression models, for example, are widely used to establish relationships between dependent variables, such as total procurement costs, and independent variables, such as supplier pricing or demand levels. Multiple regression models build on this concept by incorporating more independent variables, offering a more nuanced view of cost determinants (Mumtaz, Ali, & Petrillo, 2018).

Another critical type of econometric model is the time-series model, which analyzes data collected over specific intervals. Time-series analysis is particularly useful in healthcare procurement, as it enables organizations to track spending patterns, identify seasonal fluctuations, and predict future procurement needs. Stochastic frontier analysis (SFA) is another advanced econometric approach often used to measure efficiency. This model distinguishes between random errors and inefficiencies in the system, providing a clearer understanding of where resources may be wasted (H. M. Nguyen, Turk, & McWilliams, 2021).

Panel data models, which analyze multi-dimensional data involving measurements over time, are also particularly suited for healthcare procurement. These models allow for comparisons across different healthcare facilities, regions, or procurement periods, helping stakeholders identify best practices and areas for improvement. Through these models, econometrics offers a structured, data-driven approach to addressing cost-related challenges in procurement systems (Dabbous, Barakat, & Kraus, 2023).

## 2.2. Relevance to Healthcare Procurement

The application of econometric models to healthcare procurement lies in their ability to identify inefficiencies and predict cost-saving opportunities. Healthcare procurement is inherently complex, involving multiple stakeholders, diverse suppliers, and stringent quality requirements. Furthermore, external factors such as market volatility, inflation, and regulatory changes significantly influence procurement costs. Econometric models systematically analyze these complexities, offering insights that traditional cost analysis methods may overlook. For example, regression models can help determine how supplier pricing strategies impact overall procurement costs. Healthcare administrators can prioritize areas for negotiation or improvement by identifying key cost drivers. On the other hand, time-series models enable organizations to anticipate future demand for medical supplies, reducing the risk of overstocking or stockouts. This predictive capability is crucial in healthcare, where supply disruptions can have life-threatening consequences (Singh, Chakraborty, & Sehgal, 2023).

Econometric models also play a critical role in evaluating supplier performance. Stochastic frontier analysis, for instance, can be used to assess the relative efficiency of different suppliers. Healthcare organizations can streamline their procurement processes and foster long-term, cost-effective partnerships by identifying those who provide the best value for money. In addition, econometric models facilitate benchmarking and policy evaluation (Mishra, Sinha, Thirumalai, & Van de Ven, 2020). Panel data models allow healthcare systems to compare procurement practices across facilities or regions, highlighting areas where efficiency can be improved. Policymakers can also use these models to assess the impact of regulatory changes or policy interventions on procurement costs, ensuring that such measures achieve their intended outcomes without unintended financial burdens (Moreno-Serra, Anaya-Montes, & Smith, 2019).

In summary, integrating econometric models into healthcare procurement enables organizations to move beyond reactive decision-making. By providing actionable insights rooted in data, these models empower stakeholders to optimize procurement strategies, enhance cost efficiency, and ensure the availability of critical medical resources.

## 2.3. Key Variables and Indicators

To effectively evaluate cost efficiency in healthcare procurement, it is essential to identify and measure the right variables and indicators. These variables fall into several categories, each capturing a specific aspect of procurement performance. One critical set of variables relates to procurement costs. These include the unit cost of medical supplies, total expenditure, and administrative costs associated with procurement activities. Monitoring these variables provides a baseline for evaluating overall spending and identifying cost-saving opportunities.

Supplier-related variables are another key focus area. Metrics such as supplier reliability, lead times, and pricing structures help assess the value delivered by different suppliers. Econometric models can also incorporate variables related to supplier competition, enabling organizations to understand how market dynamics influence procurement costs.

Demand-side variables, such as order frequency and volume, significantly affect cost efficiency. Higher order volumes often lead to economies of scale, while frequent orders may incur additional administrative costs. Understanding these dynamics allows organizations to optimize their ordering practices and reduce costs (Callaway, Fowlie, & McCormick, 2018).

External factors, such as inflation rates, exchange rates, and regulatory changes, also impact procurement costs. Incorporating these variables into econometric models ensures a comprehensive analysis that accounts for the broader economic and policy environment.

Performance indicators such as procurement cycle time, inventory turnover rates, and stockout frequencies are also crucial for assessing efficiency. These indicators provide insights into how well the procurement system functions and whether it meets the organization's needs without incurring unnecessary costs (Ramin, Spinelli, & Brusaferrri, 2018). Lastly, patient-related variables, such as service utilization rates and population health trends, indirectly influence procurement efficiency. For instance, an increase in patient admissions may drive up demand for medical supplies, necessitating adjustments in procurement strategies. Healthcare organizations can gain a holistic understanding of cost

efficiency by systematically analyzing these variables through econometric models. This approach identifies areas for improvement and provides a solid foundation for evidence-based decision-making, ensuring that procurement practices align with organizational goals and resource constraints (Ha, Kose, & Ohnsorge, 2019).

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### 3. Challenges and Opportunities

#### 3.1. Challenges in Healthcare Procurement

Healthcare procurement is a complex process, fraught with challenges that hinder cost efficiency and operational effectiveness. One of the most pressing issues is budget constraints. Healthcare systems worldwide operate under tight financial limits, often balancing the demand for high-quality medical supplies and services with limited resources. This challenge is particularly acute in low- and middle-income countries, where funding shortfalls can result in delayed purchases, stockouts, and a reliance on less reliable suppliers, ultimately compromising patient care (Lugada et al., 2022).

Another significant challenge is market volatility, which introduces unpredictability into procurement planning. Fluctuating prices for medical supplies, currency exchange rate changes, and disruptions in global supply chains, such as those seen during the COVID-19 pandemic, can create significant procurement inefficiencies. These issues often force healthcare organizations to pay premium prices or settle for suboptimal products, further straining limited budgets (Hong, Lee, & Zhang, 2018).

Supplier dynamics also play a critical role in healthcare procurement challenges. The reliance on a few suppliers for essential products can lead to monopolistic practices, such as inflated pricing and reduced buyer bargaining power. Conversely, working with too many suppliers can complicate procurement processes, increase administrative overhead, and hinder the development of long-term, cost-effective partnerships. Inconsistent supplier performance, including late deliveries and subpar product quality, further exacerbates inefficiencies, making it difficult for healthcare organizations to maintain reliable operations (Schweitzer & Lu, 2018).

The lack of standardized procurement practices across regions or institutions adds another layer of complexity. Without uniform guidelines, healthcare facilities often face disparities in pricing, quality, and accessibility, leading to inefficiencies that could be avoided through coordinated efforts and centralized purchasing strategies (Barber, Lorenzoni, & Ong, 2019).

#### 3.2. Modeling Complexities

While econometric models offer immense potential for optimizing procurement processes, their implementation is challenging. One of the most significant hurdles is data availability and quality. Effective econometric modeling requires robust, high-quality datasets that capture key variables such as procurement costs, supplier performance, and demand patterns. However, healthcare procurement data is often fragmented, inconsistent, or incomplete, limiting the accuracy and reliability of these models.

Data collection systems in many healthcare organizations are not designed to support advanced analytics. For instance, procurement records may be maintained manually or stored in disparate systems that lack integration. This creates difficulties in aggregating and standardizing data for econometric analysis. Furthermore, privacy concerns and regulatory restrictions around healthcare data can limit access to critical information, especially in jurisdictions with stringent data protection laws.

Another challenge lies in the technical expertise required to develop and apply econometric models. Building effective models demands a strong understanding of both statistical methodologies and the intricacies of healthcare procurement. Many healthcare organizations lack in-house expertise in econometrics, necessitating costly investments in training or external consultants.

The interpretation of model results is another area of concern. While econometric models generate valuable insights, translating these findings into actionable strategies requires interdisciplinary collaboration between data analysts, procurement officers, and healthcare administrators. Misinterpretation or oversimplification of model outputs can lead to suboptimal decisions, undermining the potential benefits of econometric analysis. Finally, there is the issue of scalability. Econometric models that work well for one healthcare facility or region may not apply directly to others due to differences in procurement practices, market conditions, and healthcare needs. Developing adaptable models that accommodate these variations remains a significant challenge for researchers and practitioners.

### 3.3. Opportunities for Innovation

Despite these challenges, healthcare procurement presents numerous opportunities for innovation, particularly through advances in data analytics and artificial intelligence (AI). These technologies have the potential to overcome many of the limitations associated with traditional econometric models, enhancing their accuracy, usability, and impact. One major opportunity lies in the integration of big data analytics. Modern healthcare systems generate vast amounts of data from electronic health records, inventory management systems, and financial transactions. By harnessing this data, econometric models can gain access to richer datasets, improving their ability to identify patterns and predict outcomes. Advanced data visualization tools can also make model outputs more accessible to decision-makers, facilitating better-informed procurement strategies (Agarwal et al., 2022).

AI and machine learning (ML) represent transformative innovations in econometric modeling. These technologies can handle complex, high-dimensional datasets more efficiently than traditional econometric methods, uncovering relationships and trends that might otherwise go unnoticed. For example, ML algorithms can predict supplier reliability or anticipate price fluctuations with remarkable precision, enabling healthcare organizations to proactively address potential issues (D. K. Nguyen, Sermpinis, & Stasinakis, 2023).

Another promising development is the use of cloud-based platforms for data storage and analytics. These platforms allow healthcare organizations to consolidate and share procurement data securely, fostering collaboration and enabling the development of more comprehensive econometric models. Cloud-based solutions also facilitate real-time analysis, allowing organizations to respond quickly to changes in market conditions or procurement needs (Shah & Konda, 2022).

The growing emphasis on blockchain technology in supply chain management offers additional opportunities for innovation. Blockchain provides a transparent, tamper-proof record of transactions, enhancing trust and accountability in procurement processes. By integrating blockchain data into econometric models, healthcare organizations can gain deeper insights into supplier performance, pricing trends, and supply chain efficiency (Manda, 2021). Finally, the shift toward value-based procurement in healthcare aligns well with the capabilities of econometric models. Value-based procurement prioritizes outcomes and long-term cost-effectiveness over short-term savings, making econometric models ideal for evaluating trade-offs and optimizing resource allocation. This approach enhances cost efficiency and contributes to improved patient care and system sustainability (Kumar, Liu, & Shan, 2020).

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## 4. Proposed Framework for Evaluation

### 4.1. Conceptual Design

A high-level framework for applying econometric models in healthcare procurement begins with defining the objectives of the analysis. The primary aim is to identify inefficiencies, forecast future procurement needs, and optimize resource allocation to achieve cost efficiency. This requires a structured approach that integrates economic theory, statistical methods, and healthcare-specific considerations into the modeling process.

The framework comprises three core pillars: data integration, model selection, and decision-making alignment. Data integration involves consolidating diverse datasets into a unified system, such as procurement records, supplier performance metrics, and external economic indicators. This ensures that the models are informed by comprehensive and accurate data, improving their reliability.

Model selection focuses on choosing the appropriate econometric techniques based on the nature of the data and the specific procurement challenges being addressed. For instance, linear regression models may be used to explore the relationship between procurement costs and supplier reliability, while time-series models can predict future demand for medical supplies. Advanced techniques such as stochastic frontier analysis may be employed to assess efficiency levels across suppliers or regions.

Decision-making alignment ensures that the insights generated by the models are actionable and relevant to the organization's procurement goals. This involves close collaboration between data analysts, procurement officers, and healthcare administrators to translate complex statistical findings into practical strategies. The ultimate goal is to create a feedback loop where model results inform procurement decisions and the outcomes of these decisions are used to refine the models over time.

## 4.2. Implementation Steps

The proposed framework consists of several key stages:

**Data Collection:** The first step involves gathering relevant data from internal and external sources. Internal data includes procurement costs, order volumes, supplier performance metrics, and inventory records. External data encompasses market trends, inflation rates, and regulatory changes that may impact procurement costs. This stage also requires ensuring data quality by addressing issues such as missing values, inconsistencies, and errors.

**Data Integration and Preparation:** Collected data is then integrated into a centralized system, such as a cloud-based platform, to enable seamless analysis. The data is cleaned and standardized to ensure compatibility with econometric modeling techniques. For example, categorical variables may be encoded numerically, and time-series data may be aligned to a consistent timeline.

**Model Development:** This stage involves selecting and developing econometric models based on the defined objectives. For example, regression analysis may be used to determine the factors influencing procurement costs, while panel data models could compare efficiency across different facilities. The models are then calibrated using historical data to ensure accuracy and relevance.

**Validation and Testing:** Before the models are applied to real-world scenarios, they must be validated to ensure their reliability. This involves testing the models on a subset of data and comparing their predictions to actual outcomes. Validation helps identify potential biases, inaccuracies, or limitations in the models, allowing for necessary adjustments.

**Result Interpretation and Visualization:** The results generated by the models are analyzed and presented in a user-friendly format, such as dashboards or visualizations. This makes it easier for decision-makers to understand key insights and apply them to procurement strategies. For instance, a dashboard might highlight cost-saving opportunities based on supplier performance metrics or predict future procurement needs based on demand patterns.

**Decision-Making and Feedback:** The insights derived from the models are used to inform procurement decisions, such as negotiating contracts with high-performing suppliers or adjusting order volumes to align with predicted demand. The outcomes of these decisions are then monitored and fed back into the framework, creating a continuous improvement cycle.

## 4.3. Anticipated Outcomes

The proposed framework can potentially deliver several significant outcomes, enhancing cost efficiency and healthcare procurement decision-making. One of the most tangible benefits is cost savings. Healthcare organizations can reduce unnecessary expenditures and allocate resources more effectively by identifying inefficiencies and optimizing procurement strategies. For example, econometric models might reveal that consolidating orders across departments leads to volume discounts, or that switching to a more reliable supplier reduces costs associated with delays and product defects.

Another anticipated outcome is improved forecasting accuracy. Time-series models and predictive analytics enable organizations to anticipate future procurement needs, reducing the risk of overstocking or stockouts. This is particularly critical in healthcare, where supply shortages can compromise patient care, and excess inventory can lead to wastage.

The framework also enhances supplier management by providing a data-driven basis for evaluating supplier performance. This allows organizations to build stronger relationships with high-performing suppliers and address issues with underperforming ones. For instance, stochastic frontier analysis might highlight suppliers consistently delivering high-quality products at competitive prices, enabling procurement officers to prioritize these partners in future contracts.

Furthermore, the framework supports evidence-based policy-making. By generating actionable insights into procurement practices, econometric models enable policymakers to design targeted interventions that address specific inefficiencies. For example, panel data analysis might reveal regional disparities in procurement costs, prompting initiatives to standardize pricing or improve supply chain logistics. Lastly, the proposed framework fosters a culture of continuous improvement. The feedback loop embedded in the framework ensures that procurement strategies evolve in response to changing conditions and emerging insights. This adaptability is essential in a dynamic environment where healthcare needs, market conditions, and regulatory requirements constantly shift.

## 5. Conclusion and Recommendations

This paper has explored the critical role of econometric models in enhancing cost efficiency in healthcare procurement systems. Theoretically, it highlighted the foundational principles and applications of econometric models, including their ability to analyze procurement costs, predict future needs, and optimize resource allocation. By connecting these models to the unique challenges of healthcare procurement, such as budget constraints, market volatility, and supplier dynamics, the paper underscored their relevance in addressing inefficiencies and improving decision-making.

The proposed framework provided a structured approach to implementing econometric models, encompassing data collection, integration, model development, and feedback-driven improvement. Practical insights included identifying key variables—such as supplier reliability, demand trends, and market conditions—that drive cost efficiency. Additionally, the paper recognized the challenges of data availability, modeling complexities, and technical expertise, pointing to opportunities for innovation through advanced analytics, artificial intelligence (AI), and blockchain technology.

Together, these insights demonstrate the transformative potential of econometric models in healthcare procurement. By offering data-driven solutions to long-standing inefficiencies, these models promise to enhance financial sustainability, improve supplier management, and ensure the timely availability of medical supplies, ultimately benefiting patients and healthcare providers alike.

To harness the full potential of econometric models, stakeholders in healthcare procurement should consider the following recommendations. Policymakers should prioritize the development of regulatory frameworks that support the integration of econometric models into healthcare procurement systems. This includes promoting data standardization across institutions and regions to ensure the availability of high-quality, comparable datasets. Policies should also incentivize the adoption of advanced analytics tools, such as AI-driven modeling and blockchain-based supply chain solutions, to enhance procurement transparency and efficiency.

Additionally, governments and international organizations can facilitate capacity-building initiatives by funding training programs in econometric modeling for procurement professionals. These programs can bridge the gap between theoretical expertise and practical application, empowering stakeholders to make informed, data-driven decisions.

Procurement officers should invest in robust data management systems to effectively collect, integrate, and analyze procurement data. Transitioning from manual processes to automated, cloud-based platforms can improve data accuracy and accessibility, enabling the successful application of econometric models. Officers should also establish interdisciplinary teams that bring together data analysts, supply chain experts, and healthcare administrators to ensure that model results are interpreted and implemented effectively. Procurement teams can develop strategies that balance cost efficiency with quality and reliability by fostering collaboration.

Researchers and developers should focus on creating customizable econometric models that can adapt to the diverse needs of healthcare organizations. This includes designing user-friendly interfaces and visualization tools to make complex model outputs accessible to non-experts. Collaboration with healthcare providers is essential to validate and refine these models. Pilot projects and case studies can provide valuable insights into the practical challenges and benefits of applying econometric models, paving the way for their broader adoption.

Healthcare institutions should adopt a proactive approach to integrating econometric models into their procurement processes. This involves investing in the necessary infrastructure and expertise and fostering a culture of continuous improvement. Regularly reviewing and updating procurement strategies based on model outputs can help institutions stay responsive to changing market conditions and healthcare needs.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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