

# Research on the Application of Big Data Technology in Comprehensive Budget Performance Management

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## ABSTRACT

Since the 19th National Congress of the Communist Party of China first proposed the comprehensive implementation of budget performance management, building a comprehensive, all-encompassing, and fully integrated budget performance management system has become a key focus of the Chinese government. In recent years, big data technology has advanced rapidly and found wide application across various sectors of society. The question of how to effectively apply big data technology to comprehensive budget performance management has emerged as a central concern for the government. This paper, based on the practical application of big data technology in China's budget performance management, explores issues currently present in budget performance management practices, focusing on areas such as performance indicator systems, database platform construction, evaluation management, and the application of results. Furthermore, it analyzes the application practices of big data technology in budget performance management abroad, providing insights into the implications for China's own practices.

## KEYWORDS

Big Data Technology; Budget Performance; Comprehensive Budget Performance Management; Database Platform Construction; Performance Evaluation

## 1. INTRODUCTION

In recent years, big data technology has rapidly developed and found widespread application across various sectors of society, making its integration into government management a focal point of the era. The application of big data technology in comprehensive budget performance management holds significant theoretical and practical implications.

From a theoretical perspective, economics primarily studies the rational allocation of limited resources within society. Public goods and services provided by the public sector through budgeting are also limited resources, and their allocation must adhere to the principles of fairness and efficiency. According to Buchanan's theory, governments often experience resource waste when providing public goods, failing to achieve optimal resource allocation. Therefore, studying the efficient and rational allocation of budgetary funds is of great importance. Applying big data technology in budget performance management can help reduce administrative costs, enhance the efficiency of budgetary fund utilization, and ultimately improve resource allocation efficiency. The integration of big data with budget performance management represents an expansion of China's public financial system in the new era, contributing to the improvement of the public financial performance evaluation system, and thus holds considerable theoretical value.

From a practical perspective, firstly, in recent years, under the impact of the pandemic, the state has implemented a series of tax reduction and fee-cutting policies to stimulate stable economic development, leading to a slowdown in the growth of fiscal revenues while fiscal expenditures remain rigid. At this time, the use of big data technology to promote the comprehensive implementation of budget performance management can help meet the requirement of "tightening the belt" and better regulate fiscal revenue and expenditure behavior, thereby promoting the rational allocation of fiscal funds, improving budget execution quality, and enhancing resource allocation efficiency. Secondly, China's current budget performance management system encompasses both structured and unstructured information. Compared to traditional structured systems, the current system is more complex and involves massive volumes of financial data. The application of big data technology in comprehensive budget performance management aids in scientifically and accurately handling complex and voluminous financial data, thereby establishing a modern public financial system. Finally, with the development of the economy and society, the public has begun to pay attention to the government's use of fiscal funds and the efficiency of their outputs. The application of big data technology in budget performance management contributes to improving the scientific rationality of fiscal expenditure direction, the efficiency of fiscal fund outputs, and the transparency of fiscal information, further promoting government information disclosure and ultimately enhancing government credibility. Based on this, the paper focuses on the practical application of big data technology in China's comprehensive budget performance management, identifies current issues in practice, and analyzes the application practices of big data technology in budget performance management abroad to provide insights for improving budget performance management in China.

## **2. OVERVIEW OF THE APPLICATION OF BIG DATA TECHNOLOGY IN COMPREHENSIVE BUDGET PERFORMANCE MANAGEMENT**

In terms of necessity, big data technology can enhance the quality of budget performance management through four specific ways: scientific evaluation of budget performance targets, accuracy of performance assessments, real-time monitoring of performance operations, and visualization of performance information (Li Wenbin & Xie Xin, 2020). Wang Min and Peng Minjiao (2019) liken big data technology to a neural network that can be applied to all aspects and the entire process of comprehensive budget performance management. Yu Changjin (2020) believes that big data technology can play an active role in the all-encompassing, all-process, and fully integrated budget performance management. Similarly, Li Yaping (2021) argues that applying big data technology in comprehensive budget performance management can effectively improve budget efficiency and promote performance growth.

Regarding feasibility, several studies have explored the technical pathways for applying big data technology to comprehensive budget performance management. Professors Ma Caichen and Zhao Di (2019) discussed the initial research framework for establishing a government budget performance indicator system using big data analysis technology in various aspects such as government system construction, information dissemination, and functional applications, which is of great significance for all-process budget performance management. The Zhejiang Provincial Audit Association Research Group (2020), from an audit perspective, studied methods to improve the performance of national fiscal funds under a more comprehensive government performance control background. They proposed constructing a big data analysis audit model to enhance the quality and efficiency of performance audits of national fiscal funds. Specifically, they suggested three paths: building a robust fiscal database system, promoting a big data audit model, and improving big data audit working systems.

Compared to small data, big data has more significant advantages, but its application in the public sector is still immature. Its application in data collection, mining, and analysis faces various constraints such as incomplete data, unusable data, and limited data sources (Wu Zhenqi & Guo

Chengcheng, 2022). Additionally, Vydra and Klievink (2019) argue that the current application of big data in budget performance management overemphasizes technical rationality at the expense of political decision-making, whereas there should be a balance between the two. Moreover, closely related to this are the ethical issues brought about by big data.

Although the understanding of big data technology in government comprehensive budget performance management is still relatively novel, big data has long been a hot topic, and significant progress has been made in academia regarding its application in government management. However, there are relatively few studies combining big data technology with comprehensive budget performance management. Research on the practical application of big data technology in comprehensive budget performance management can partially fill this research gap and represents an attempt to contribute to the eventual establishment of an all-encompassing, all-process, fully integrated government budget performance management system in China.

### **3. PRACTICAL APPLICATIONS OF BIG DATA TECHNOLOGY IN COMPREHENSIVE BUDGET PERFORMANCE MANAGEMENT**

#### **3.1. Big Data Technology and Performance Target Management**

Big data technology's data analysis capabilities provide crucial references for setting performance targets. It significantly enhances data analysis efficiency in areas such as data collection, storage, processing, statistical analysis, and correlation analysis, which aids in the scientific and rational formulation of performance targets. Additionally, big data analysis technology makes it possible to synchronize performance indicator management with budget preparation, thereby promoting the simultaneous review and execution of performance indicators and plans, aligning with the goal of “unifying planning and performance work” as outlined in government guidelines.

In practice, big data technology can efficiently analyze and process data, providing critical evidence for setting performance targets. For example, the Shenzhen Municipal Finance Bureau utilizes big data technology to conduct both longitudinal and horizontal analyses of historical projects within the city, as well as similar projects in the same industry and region. This approach has gradually established a performance indicator and standard database tailored to Shenzhen's comprehensive budget performance management needs, with unified specifications and management for functional modules and technical standards. By 2022, Shenzhen solidified the foundation of budget performance management using an “integrated” approach, establishing a performance indicator system comprising 21 major categories, 65 subcategories, 293 expenditure directions, and a total of 7,750 performance indicators. This system supports the “Smart Finance” information system, which integrates budget and performance management, enabling the synchronized flow of budget and performance indicators within the “three databases and two zones” project database. It achieves integration in responsibilities, processes, indicators, and data statistics. Moreover, the Shenzhen Municipal Finance Bureau synchronizes performance plan management with government budget preparation using big data analysis tools, ensuring that “wherever the budget preparation goes, performance target approval follows.” This approach categorizes the pre-evaluation of performance and performance targets, integrating basic performance management requirements into each phase of the budget preparation process, to achieve simultaneous formulation, review, and disclosure of performance targets and plans. Additionally, the Bureau uses big data analysis to achieve comprehensive coverage of performance projects, managing both project personnel and implementation of special funds, thus fulfilling the requirements of comprehensive budget performance management.

### **3.2. Big Data Technology and Performance Monitoring**

Big data comparison and analytical techniques, based on fiscal big data platform databases, play a crucial role in monitoring and early warning of performance operations. The general model involves three steps: First, establish a standard indicator database that includes performance operation requirements at various time points, clearly defining comparison items and values. Second, create a real-time performance operation results database through automatic data capture or manual input. Third, at each time point, the standard indicator database sends data flow instructions to the results database, conducts comparisons and variance detection, and generates automatic instructions and reports based on the detection results.

In practice, some regions have established integrated fiscal data platforms to enable real-time early warning and comprehensive analysis of budget performance operations. For example, since 2013, the Foshan Municipal Finance Bureau has implemented a mid-process budget performance monitoring reform, becoming a critical component of building an all-process budget performance management system. Foshan pioneered the concept of big data performance monitoring, fostering the integration of internal and external monitoring by developing both an internal performance monitoring system and an external performance monitoring network system. Internally, Foshan's performance monitoring system leverages the advantages of the integrated fiscal platform by defining monitoring rules and innovating with online automatic early warning functions. The automatic early warning triggers when the quarterly fund utilization rate of a project falls below the rate set by the unit during the project application. The integrated fiscal platform automatically issues warnings to the unit, enabling dynamic internal automatic monitoring of project performance progress and significantly enhancing monitoring efficiency. Externally, the Foshan Municipal Finance Bureau synchronizes internal monitoring data from the integrated platform with the external performance monitoring network system, allowing experts to access the system via the internet for real-time, convenient professional monitoring and quickly feedback their opinions to the finance department and budget units.

### **3.3. Big Data Technology and the Application of Performance Evaluation Results**

Currently, the practical application of big data technology in performance evaluation results mainly focuses on the disclosure of these results. Big data technology can present large volumes of data and their basic analysis in a clear and concise visual format, improving the clarity and comprehensibility of disclosed performance evaluation results.

In practice, the combination of data visualization with fiscal data platforms can significantly enhance the application efficiency of performance evaluation results. For example, the Yunnan Provincial Finance Department has developed a fiscal fund monitoring and analysis platform that can dynamically obtain real-time data on fiscal revenue and expenditure, fund operation, and accounting at all levels. The platform allows for thematic, layered, and multi-angle comprehensive analysis and deep utilization of data, presenting the province's fiscal "revenue and expenditure map" and fiscal fund operation in a visual, traceable chart format. Similarly, the Audit Bureau of Jiayuguan City in Gansu Province has implemented a visualization analysis method for department budget execution data, where the interactive interface can display the overall relationship and fund amounts of the city's primary and secondary budget units. A single chart can clearly show the flow of funds within the budget units, and by adjusting key parameters in the analysis model, the same foundational model can display the budget execution status of different units across different years. If such interactive visualization pages for performance evaluation were synchronized or periodically updated on the budget performance management section of the fiscal department's official website, it would better achieve the disclosure of budget performance evaluation and strengthen public oversight. However, it is worth noting that the current attempts at visualization by various levels of government in China remain limited. Data analysis and utilization often remain at the stage of simple chart statistics and

visual presentations, with relatively few examples of using professional analysis tools to explore underlying data patterns for public display.

## **4. EXISTING ISSUES IN THE APPLICATION OF BIG DATA TECHNOLOGY IN COMPREHENSIVE BUDGET PERFORMANCE MANAGEMENT**

### **4.1. Incomplete Budget Performance Indicator System and Weak Foundation for Performance Target Management**

Currently, in China, different regions and departments face issues with budget performance indicators, such as identical terms with different meanings or different terms with the same meaning. These inconsistencies significantly hinder horizontal comparisons of similar projects across regions and departments, potentially leading to misleading decisions in budget performance management. Additionally, the widespread establishment of budget performance indicator databases has not yet been realized, and the existing databases often lack a big data mindset, remaining rooted in the small data era. The indicators typically include only basic information like categories, names, standard values, and weightings, with limited data content and analyzability. The data is often presented in basic table formats, making it cumbersome and inconvenient for further data processing. Data filtering is also challenging, as most databases only offer basic summary classifications without considering the various needs of users, lacking platforms for data filtering, and failing to provide longitudinal analysis of historical data for similar projects or horizontal comparisons across regions. In summary, the quality of the budget performance indicator system as foundational data is subpar, which, to some extent, impedes the application of big data mining and analysis technologies in comprehensive budget performance management.

### **4.2. Slow Development of Budget Performance Database Platforms and Impediments to Performance Monitoring**

In 2019, to continue advancing the national budget management system reform, the Ministry of Finance issued the “Central Business Integration Management System Plan,” initiating a unified reform of the budget management system. In February 2020, the Ministry further issued the “Budget Management Integration Standards (Trial),” which provided additional guidelines for establishing a unified budget management information system across all levels nationwide. Over the past three years, all 31 provinces in China have developed national-level budget management integrated information systems, making significant progress in breaking down information silos and improving budget performance management efficiency.

However, the implementation of these integrated systems is relatively recent, with the longest duration being just under three years, and their application to budget performance management is still in the exploratory phase. Various regions have encountered numerous issues after these systems went live. First, there are functional deficiencies in the systems, such as the inability to modify fund amounts during the allocation of indicators. Second, the systems lack stability, frequently crashing during actual operations, which significantly reduces work efficiency. Third, the systems suffer from poor maintenance capabilities; due to insufficient training, grassroots financial personnel are often unfamiliar with the full range of system functions and unable to promptly resolve issues when they arise. Furthermore, some maintenance staff possess technical knowledge without a clear understanding of financial operations, leading to a disconnect between technical and business aspects. The current lack of a mature, stable integrated information platform and skilled maintenance personnel poses significant challenges to the effective use of big data analysis technology in government budget performance control.

### **4.3. Delayed Impact of Budget Performance Management and Gaps in the Application of Performance Evaluation Results**

Since the application of budget performance evaluation results occurs after project completion, the issues identified and successful experiences highlighted in the evaluation can only benefit future projects, not those already completed. Therefore, if the budget performance evaluation results are not fully disclosed and shared, it will severely hinder the ongoing improvement of measures and the widespread dissemination of successful experiences. Regarding the presentation of budget performance evaluation results, the current method involves budget performance evaluation reports, which are manually written and thus highly subjective. Moreover, these reports often consist of mere lists of text and numerical data, making them difficult to understand and lacking readability, let alone effectively applying the evaluation results in the next budget preparation cycle. The subjective nature of government budget performance evaluation results and the obscure presentation format make it challenging to apply these results, thereby limiting the full potential of big data technology benefits.

## **5. INTERNATIONAL EXPERIENCES IN APPLYING BIG DATA TECHNOLOGY TO BUDGET PERFORMANCE MANAGEMENT**

### **5.1. Determination of Budget Performance Indicators**

Comprehensive and reliable data is crucial for establishing scientific and rational budget performance indicators. The sources of data for setting these indicators include surveys, scale information, research content, and interview data. The comprehensiveness and accuracy of these fundamental data sources are vital for determining budget performance indicators. Many countries have enhanced the transparency of financial data and enriched the sources of budget performance indicators by using big data technology to build open government data websites.

For instance, the UK has developed the open government data website [gov.uk](http://gov.uk) to improve financial data transparency and broaden the data sources for budget performance indicators. This platform makes government-related data, such as the use of public funds, available to the public and collects user interaction data like browsing, downloading, and feedback to enhance public service delivery. Similarly, the U.S. and Japanese governments have created their own open government data websites to better disclose government-related data to the public.

### **5.2. Construction of Budget Performance Database Platforms**

The U.S. federal government has accumulated relatively mature experience in budget performance database construction and cross-departmental collaboration. [USAspending.gov](http://USAspending.gov) serves as the official source of U.S. government spending data, showcasing the federal budget's annual expenditures and methods of allocation. A key feature of this platform is the timeliness of big data updates. The budget data is directly uploaded from over 100 federal agencies and other government systems, with more than 400 data sources in total.

For example, contract award information is extracted daily from the Federal Procurement Data System-Next Generation (FPDS-NG), while financial assistance data is loaded from the Financial Assistance Broker Submission (FABS) system. Federal agencies are required to submit contract, grant, loan, direct payment, and other award data at least twice a month, and financial data quarterly. Quarterly data must be certified by a senior official of the agency before being displayed on the website. Since the outbreak of COVID-19, agencies receiving pandemic relief funds have been required to submit their account data monthly to FABS, involving most agencies that regularly report financial data to [USAspending.gov](http://USAspending.gov). Starting in the first quarter of 2022, all other agencies must also report monthly instead of quarterly, with updated data visible on the website the day after submission.

USAspending.gov also offers valuable insights into budget data transparency and interactivity. The platform's budget browser allows users to search data categorized by budget item, agency, and project type, with clear instructions for each category and operation step. The browser visually explains the proportions of expenditures across various levels using intuitive proportional graphics. Users can click on each category to expand and explore budget allocation details at different levels, with high interactivity. Additionally, structured budget data can be downloaded directly in table format. This easy and straightforward operation method lowers the barriers to accessing information compared to traditional budget performance reports and tables, significantly enhancing public oversight of budget performance.

### **5.3. Application of Budget Performance Results**

The Australian government also places great emphasis on the transparency of government budget data. In 2013, Australia launched its Big Data Strategy and established a comprehensive Government Data Analytics Centre to improve data management capabilities and government performance. Australia views the vast amount of data generated through government decision-making and interactions with the public as a national asset belonging to both the government and the Australian public. The government believes that better information sharing enables the public to assist in government oversight, participate in project management, and provide a basis for performance evaluations that inform decision-making.

To promote the public use of federal government budget data and enhance budget performance management, the Australian government has enacted the Public Sector Information (PSI) Principles through the data.gov.au website. Additionally, the Australian government increasingly seeks to collaborate with third-party organizations to provide analysis or support services based on government data, such as developing mobile applications, further integrating big data into budget performance management.

## **6. CONCLUSIONS AND RECOMMENDATIONS**

### **6.1. Building a Budget Performance Indicator System Based on Big Data Technology**

The effective application of big data technology to the budget performance indicator system requires the establishment of a standardized, nationwide budget performance indicator database with dynamic updates. This would address the current issues of inconsistent definitions and interpretations of performance indicators, facilitating their setting, monitoring, and evaluation. The database should not only include historically successful budget performance indicators for policymakers to reference but also offer modules for setting new indicators based on big data analysis and mining. Policymakers can utilize big data to deeply analyze economic activities, considering the allocation of necessary resources such as funds, manpower, and technology, to create data models for simulation and ultimately set new budget performance indicators and target values.

### **6.2. Promoting the Construction of Budget Performance Database Platforms Based on Big Data Collection Technology**

For big data technology to be deeply and comprehensively applied in performance monitoring, it is essential to build a budget performance indicator database and integrate it with a unified budget management platform. The budget performance database can be further enhanced by utilizing big data collection techniques such as web data scraping to acquire external macroeconomic, industry, and regional public data. Additionally, database collection techniques should be used to gather data generated and uploaded by various government levels during daily operations. After collection, this

data should be stored in the performance indicator database. Accelerating the construction of the integrated budget management platform also requires breaking down the "information silos" between departments and units while establishing specialized departments for professional development and operation. However, it is crucial to ensure that information security requirements are strictly followed when eliminating these silos.

### **6.3. Application of Big Data Visualization Technology in Budget Performance Disclosure and Results Utilization**

Big data processing, analysis, and mining technologies can be applied to budget performance evaluation, with big data visualization technology playing a significant role in budget performance disclosure. Instead of relying solely on complex and difficult-to-understand performance evaluation reports, governments can use visualization techniques to present vast amounts of performance indicators and evaluation data in an intuitive manner, thereby enhancing public oversight efficiency.

Drawing from domestic and international best practices, the following steps can be taken to improve the quality of budget performance data disclosure using big data visualization technology. First, a dedicated budget performance information disclosure website can be established, connected to the smart financial information platform's key performance indicator database, allowing for timely updates and extraction of performance data. Second, an interactive data browser interface based on big data visualization products can be incorporated into the website, enabling users to browse budget performance information by budget account, department, project type, region, and other dimensions. This would make it easier for the public to understand and engage with budget performance data at different levels. Third, in constructing visual mappings, emphasis can be placed on interpreting the meaning of indicators and providing clear graphical representations, making it simpler and more convenient for website visitors to comprehend the budget performance information presented through big data.

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