



DATA-DRIVEN PERSPECTIVES ON FEDERAL BUDGETARY DYNAMICS FOR IDENTIFYING ANOMALIES AND PATTERNS IN RESOURCE ALLOCATION AND OBLIGATION TRENDS

RAFIQUS SALEHIN KHAN¹ , MD RIAD MAHAMUD SIRAZY² , RAHUL DAS³ , SHARIFUR RAHMAN⁴ 

¹Data & Assessment Associate at Success Academy Charter Schools, NYC

²Technology Integration Associate (Information Technology), Shine Electronics Co. NYC

³Device Quality Engineer, Shine Electronics Co. NYC

⁴MSc in Business Analytics, University of Central Oklahoma, USA

Corresponding author: Khan, F. S.

© Khan, F. S., Author. Licensed under CC BY-NC-SA 4.0. You may: Share and adapt the material Under these terms:

- Give credit and indicate changes
- Only for non-commercial use
- Distribute adaptations under same license
- No additional restrictions

ABSTRACT Federal agencies tasked with significant program mandates often exhibit uneven spending patterns that can obscure broader fiscal objectives. This study investigated how major sub-components allocate and obligate resources over multiple years, seeking to identify common behaviors, anomalies, and possible influences on spending decisions. Objectives included examining efficiency, detecting outliers, and grouping sub-components according to their historical trends to guide refined budgeting practices. Methods encompassed K-means and hierarchical clustering, correlation analysis to assess alignment between resources and obligations, outlier detection through z-score and interquartile range, and linear regression to quantify directionality in spending patterns. Results highlighted several trajectories, with the “Centers for Medicare and Medicaid Services” emerging as a clear outlier due to rapid escalation in obligations that exceeded standard expectations. The “Office of Federal Student Aid” showed a contrasting scenario, underspending its allocated resources and displaying negative z-scores by 2023. Meanwhile, the “Food and Nutrition Service” maintained a balanced ratio of obligations to allocations, pointing to stable management processes. Clustering models grouped agencies into stable, quickly increasing, and fluctuating spending categories, revealing operational parallels among sub-components that share cluster assignments. Correlation tests affirmed a strong linkage between resource distribution and spending outcomes in most cases, notwithstanding a few anomalies. Recommendations highlight the importance of embedding advanced data analytics in budgetary supervision, reinforcing real-time monitoring to enable early detection of deviations and fostering inter-agency collaboration in the dissemination of best practices. Forward-looking strategies focused on adaptive budget allocations and methodological refinements promise stronger alignment between designated resources and evolving policy imperatives.

INDEX TERMS anomalies, budgeting practices, clustering models, efficiency, resource allocation, spending patterns, outlier detection

I. INTRODUCTION

Federal agencies carry out public programs of great importance, often using vast resources to achieve national priorities (Afonso & Alves, 2023; Fieldhouse & Mertens, 2023). Yet, the financial activities of federal agencies show inconsistent spending patterns throughout fiscal years. These inconsistencies, such as delayed spending, last-minute surges, or unused funds, can make it difficult for the federal government to achieve fiscal transparency, accountability, and effective

results. This paper attempts to delve into the structural, procedural, and managerial underpinnings of such patterns and their implications for broader fiscal objectives (Bouakez et al., 2023; Falsetta et al., 2024).

Fiscal practices of federal agencies are most often determined by legislative appropriations, procurement cycles, and even unexpected policy demands. To the extent that these practices are meant to provide flexibility, they sometimes create inefficiency and obscure long-term fiscal planning.

Structural, procedural, and programmatic factors are responsible for the uneven spending patterns of federal agencies. These, in turn, are related to the way budgets are appropriated, how agencies respond to fiscal deadlines, and challenges involved in managing complex procurement processes against uncertain program requirements. All the aforementioned factors contribute to an inefficient use of public finances and have implications for appropriating public resources effectively.

Appropriation and responsibilities are central to budgeting, and thus, frame the manner through which spending is carried out. Federal agencies are supposed to be annually funded through appropriation; the timing of such appropriations often does not coincide with the operational needs. Delays by the legislature in approving budgets are common and may shorten the time agencies have to plan and execute their programs. For instance, when an agency receives its funding late in the fiscal year, it is difficult to deploy resources effectively within a compressed timeline, which may lead to hurried decisions or postponed activities. Multi-year projects also face significant challenges when funded through annual appropriations. These projects need a flow of resources over time, but annual budget cycles disrupt continuity, delaying progress and increasing costs as agencies wait for the next year's funding.

Another inefficiency is reinforced by the pressure to spend all remaining funds at the end of the year, also known as the "use-it-or-lose-it" phenomenon. Agencies are incentivized to use up all their remaining funds before the fiscal year ends, fearing that unspent funds will lead to reduced budgets in the future. This has often fueled a spate of spending on non-essential items and hurried procurements that meet the requirements of the budget rules, rather than actual outcomes. This behavior distorts long-term planning because agencies stress meeting short-term expenditure targets rather than aligning spending with program goals. The pressure to spend quickly also heightens the risk of wasteful purchases and undermines efficiency in federal operations.

Other major causes of uneven spending involve the processes surrounding procurement and contracting. Federal agencies must navigate complex rules and regulations to ensure fairness, openness, and accountability in procurements. To the extent that these regulations pursue critical goals, the added complexity can also retard the process of awarding contracts and obligating funds. For example, a lengthy period can be devoted to the processing of bids, bid protests, and multiple levels of administrative approval before a contract can be awarded. Part of the problem is that agencies with urgent funding needs require timely responses, which have simply not been possible. The tension between regulatory and operational imperatives is long-standing, but it remains frustratingly hard to resolve—ensuring that programs get off the ground on time and resources are spent more evenly during the fiscal year.

Besides, programmatic constraints and uncertainty are adding to spending irregularities. Some programs, by their

very nature, require spending that is uneven. For example, emergency response programs may require significant funding in the midst of a crisis, resulting in spikes in spending unrelated to the regular fiscal calendar. Similarly, national security initiatives or large infrastructure projects often have spending needs that fluctuate significantly over time. Supplementing these innate tendencies are exogenous factors, such as altered policy mandates or changes in priorities of leadership, which could spur sudden disruptions in planned spending. In such cases of uncertainty over future directives and/or funding levels, the agencies may adopt cautious strategies, holding resources in abeyance until clearer guidance is available. This may ultimately translate into underutilization early in the fiscal year, with a rapid race to spend as the deadline draws near.

The unbalanced spending patterns in federal agencies can have very specific ramifications for fiscal discipline, outcomes from programs, long-term planning, and faith on the part of the general public. These influences underpin the inefficiencies inherent in the current processes for budgeting and spending and raise questions about general public resource management.

Accordingly, one of the critical impacts is fiscal discipline's erosion. It leads an agency with behaviors of end-of-the-year spending surges into shifting the attention to moving towards a financial deadline instead of effective and efficient usage or critical planning. The rushed buys, under this pressure from the "use-it-or-lose-it" rule, are also made without correlation to priorities in programs or consideration toward long-term needs and goals. For instance, it could be spent just but not to leave it in unused form on non-essentials. Such behavior, over time, erodes the discipline in financial management principles that require resource use to be deliberate with an alignment to policy objectives. Ultimately, this is the kind of misalignment that reduces overall effectiveness in the budgeting process and complicates efforts toward strategic resource allocation.

Irregular spending distorts program outcomes. While the federal agencies are charged to realize specific policy objectives, where spending patterns become inconsistent, prioritizing resources becomes quite insurmountable. Delays in receiving appropriations can disrupt planned activities, forcing agencies to defer important initiatives or operate on a reduced scale. Conversely, end-of-year pressures may result in hasty procurement decisions or funding reallocations that emphasize speed over impact. Such distortions hinder the ability of programs to achieve their intended results, particularly in areas where sustained and predictable funding is critical. Public health programs and infrastructure projects, for instance, can only provide quantifiable returns if investment in them is made steadily over time. The irregularities in the flow of money therefore create a drag on progress and a diminution of the effectiveness of such initiatives.

Another area of grave consequences for these irregular spending habits is multiyear planning. Many federal programs rely on funding that covers more than one fiscal

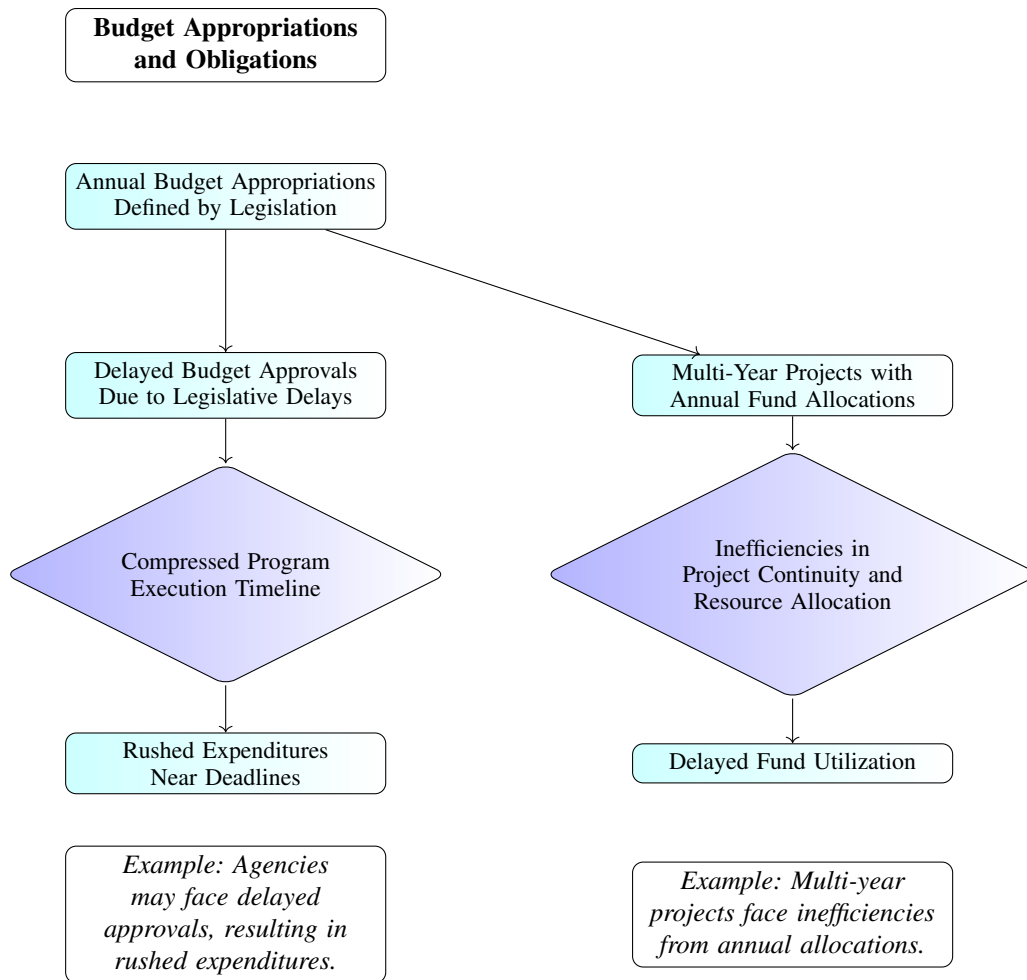


FIGURE 1. Illustration of challenges in budget appropriations and obligations. The diagram highlights two major scenarios: delays in legislative approvals that compress execution timelines, leading to rushed expenditures; and inefficiencies in multi-year project funding caused by annual fund allocations, resulting in delayed resource utilization and disrupted continuity. These scenarios underscore the misalignment between appropriations and programmatic needs.

year to achieve continuity and desired results. Long-term planning is difficult, however, when agencies are delayed in receiving funding, or are under end-of-year use-or-lose pressure. Project timelines get extended, and overall costs increase as agencies try to work around uncertain funding levels. For instance, construction or research projects may be subject to increased costs related to inflation, labor costs, or delays in procurement resulting from spasmodic funding. These inefficiencies not only increase costs but also weaken the ability of federal programs to meet their objectives within expected timeframes.

The consequences of such uneven spending even trickle down to affect the level of public confidence in government institutions. Where such spending patterns reflect inefficiencies in the form of wasted or underutilized funds, they create a perception of mismanagement among members of the general public. In spending, for instance, there is the expectation of prudent management by the government of funds placed under its disposal and a requirement to show accountability for the same. Spending in irregular patterns-especially

where it creates visible inefficiencies-undermines confidence in agencies' management of taxpayer dollars. Such erosion is most sensitive where the public policy requires high degrees of credibility and accountability, for example, in national defense, public health, or disaster response.

II. DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS)

The United States Department of Health and Human Services is a very important department in the federal government, and its establishment has aimed to improve the health of all citizens in the United States. The HHS came into being in 1980, subsequent to the splitting of the Department of Health, Education, and Welfare. It has grown into a diversified department operating multiple programs regarding the promotion of public health, medical research, and other basic human services. Guided by its mission to enhance the health and quality of life of Americans, HHS implements a number of programs to reduce health inequities, assure fair access to health care, and promote innovation in public

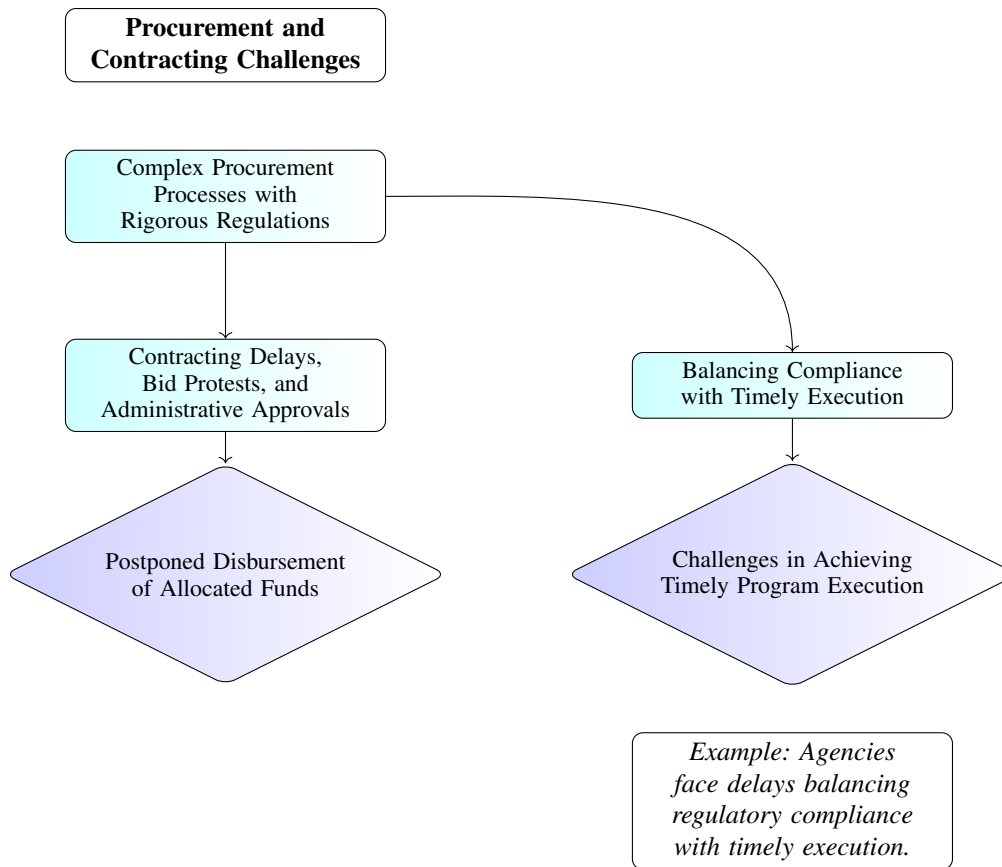


FIGURE 2. Diagram showing challenges in federal procurement and contracting processes. The illustration shows how regulations and administrative requirements can delay contracting, bid resolution, and approvals that result in postponing the disbursement of funds. Also, the tension between regulatory compliance and timely execution worsen program implementation delays that may hinder the intended fiscal outcomes.

Agency Name	Budgetary Resources (in Billion \$)	Percent of Total
Department of Health and Human Services (HHS)	2,864.47	23.39%
Department of the Treasury (TREAS)	2,203.03	17.99%
Department of Defense (DOD)	1,991.79	16.26%
Social Security Administration (SSA)	1,610.54	13.15%
Department of Agriculture (USDA)	437.20	3.57%
Department of Veterans Affairs (VA)	405.83	3.31%
Office of Personnel Management (OPM)	330.06	2.69%
Department of Transportation (DOT)	293.21	2.39%
Department of Housing and Urban Development (HUD)	283.46	2.31%
Department of Education (ED)	241.66	1.97%

TABLE 1. Budgetary Resources and Percent of Total by Agency (in Billion \$)

health and medical science. With the inner structure being rather complex, HHS includes several key divisions, each with particular areas of responsibility (Cary Jr et al., 2023).

Centres for Disease Control and Prevention: The CDC has the lead for disease control and prevention to protect the public’s health. The National Institutes of Health develops medical research for better health outcomes. It ensures that the food is safe, drugs are effective, and medical devices do not pose any threat to citizens. The Centers for Medicare Medicaid Services administer the country’s major healthcare programs: covering the nation’s senior population, persons with disabilities, and the poor. ACF’s work centers on the

set of human needs and human capital issues that involve improving the social and economic well-being of vulnerable populations. IHS provides healthcare services to American Indians and Alaska Natives. SAMHSA works to reduce the impact of substance abuse and mental illness on America’s communities. Through its extensive variety of programs, HHS attends to key health and human service needs (Kanter & Carpenter, 2023).

Medicare and Medicaid provide healthcare to the elderly, disabled, and low-income populations; the Head Start Program funds comprehensive early childhood education and support to low-income families; and HIPAA establishes stan-

dards for the security and privacy of medical records. HHS also coordinates responses to public health emergencies, including bioterrorism and natural disasters, so that America is prepared and safe (Williams et al., 2023). Biomedical research, mainly through NIH, facilitates a better understanding of diseases and the development of new treatments. With its large budget, HHS funds operations to maintain its broad array of programs.

In the fiscal year 2020, it operated on a budget of approximately \$1.293 trillion, distributed across its various divisions and initiatives. Recent developments have underlined both the new challenges and achievements that face the department. HHS has been at the front line in the response to the COVID-19 pandemic, organizing vaccine development, distribution, and public health guidance. Debates about health-care policy and reforms, especially those concerning the Affordable Care Act and Medicaid, have shaped its strategies and programs (Martin et al., 2023; Nguyen et al., 2023).

III. DEPARTMENT OF AGRICULTURE (USDA)

The United States Department of Agriculture, established by President Abraham Lincoln in 1862, is a cornerstone of the federal government in support of and regulation for the agricultural sector of the nation. Often termed "The People's Department," the USDA covers a wide spectrum of missions, from the promotion of agricultural production to food safety, protection of natural resources, fostering rural communities, and striving to end hunger both domestically and internationally (Committee et al., 2023; Llobrera et al., 2021).

It does its work through an elaborate structure of 29 agencies and offices with about 100,000 staff working in over 4,500 locations around the globe. The important constituent units are the Agricultural Research Service for scientific research for better production of agriculture; Food and Nutrition Service involved with SNAP and other nutritional assistance programs; and Forest Service for national forests and grasslands (Kingshipp et al., 2023; Schroeder et al., 2021).

For fiscal year 2024, the appropriation for USDA was about USD 437.20 billion, apportioned to its various sub-components in a manner that ensures efficiency in the delivery of its multi-faceted mandates. This covers all funding, from agricultural research and rural development through to food assistance programs and conservation (Pilgeram et al., 2020).

Beyond support for traditional farming, the role of the USDA is instrumental in foreign market development for U.S. agricultural products, ensuring the quality of the nation's food supply, and providing economic opportunities via innovation, especially in rural America.

IV. DEPARTMENT OF TRANSPORTATION (DOT)

The United States Department of Transportation was created by an act of Congress on October 15, 1966, to start operation on April 1, 1967, and is dedicated to delivering the world's leading transportation system. It is designed to ensure safe,

efficient, sustainable, and equitable transportation of people and goods to serve the public and economy of America. It is headed by the Secretary of Transportation, a member of the President's Cabinet and reporting directly to the President. The incumbent head is Pete Buttigieg, who assumed the post on 3rd February 2021 (Buttigieg, n.d.).

The USDOT operates through a series of specialized administrations that address distinct aspects of the nation's transportation infrastructure and systems. The FAA regulates civil aviation for safety and operational efficiency. The Federal Highway Administration ensures the safety and reliability of the nation's highway systems, while the FRA regulates rail transportation to maintain safety and efficiency (Aroke et al., 2021). FTA supports public transportation networks in urban and rural areas, while MARAD addresses waterborne transportation on issues related to national security, environmental concerns, and safety in port and vessel operations.

Other administrations include the National Highway Traffic Safety Administration, which works on achieving excellence in motor vehicle and highway safety standards, and the Pipeline and Hazardous Materials Safety Administration, which takes on the responsibility of ensuring a safe transportation of hazardous materials through pipelines. The Federal Motor Carrier Safety Administration regulates the trucking industry for the sustenance of safety in motor carrier operations, while the Research and Innovative Technology Administration promotes research and the implementation of technological innovations to improve the nation's transportation systems (Aviles & Van Dyke, 2023). The Bureau of Transportation Statistics provides critical data analysis and publications on transportation systems in all modes, thus enabling informed decision-making.

USDOT is central in the planning and coordination of federal transportation projects, setting safety regulations for all major modes of transportation. Its overarching objective is to maintain the safest, most efficient, and modern transportation system globally, supporting economic growth, improving quality of life, and enhancing preparedness for future challenges. In recent years, there have been major initiatives to address infrastructure and safety concerns. In September 2024, USDOT awarded \$1 billion for road safety projects as the rate of traffic fatalities remained unusually high since the start of the COVID-19 pandemic. The department also proposed new rules that would require airlines to compensate passengers for delays of more than three hours, part of a broader effort to enhance consumer protections as air travel continues growing after the pandemic (Aviles & Van Dyke, 2023; Renne et al., 2020; Tolford et al., 2023).

V. DEPARTMENT OF EDUCATION (ED)

The United States Department of Education, established on May 4, 1980, is the principal agency of the federal government for setting national policies and programs in education. The mission of the department is to promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring equal access. Its broad

Sub-Component	FY23 Total Budgetary Resources (in billions)	FY23 Obligations (in billions)
Centers for Medicare and Medicaid Services	2584.22	2173.12
Administration for Children and Families	88.26	74.77
National Institutes of Health	59.86	53.95
Departmental Management	31.89	18.71
Centers for Disease Control and Prevention	18.30	12.25
Indian Health Service	18.05	10.27
Health Resources and Services Administration	16.05	14.99
Substance Use and Mental Health Services Administration	9.41	7.99
Food and Drug Administration	8.96	7.56
Administration for Community Living	2.75	2.60

TABLE 2. FY23 Budgetary Resources and Obligations by Sub-Component (in billions).

Sub-Component	FY22 Total Budgetary Resources (in billions)	FY22 Obligations (in billions)
Centers for Medicare and Medicaid Services	2405.12	2078.60
Departmental Management	120.33	83.51
Administration for Children and Families	78.37	70.12
National Institutes of Health	55.43	50.21
Centers for Disease Control and Prevention	20.98	13.65
Indian Health Service	16.76	9.39
Health Resources and Services Administration	15.87	14.61
Food and Drug Administration	8.76	7.24
Substance Use and Mental Health Services Administration	8.30	6.12
Administration for Community Living	2.65	2.57

TABLE 3. FY22 Budgetary Resources and Obligations by Sub-Component (in billions).

Sub-Component	FY21 Total Budgetary Resources (in billions)	FY21 Obligations (in billions)
Centers for Medicare and Medicaid Services	2143.59	1877.01
Departmental Management	227.77	114.70
Administration for Children and Families	129.81	124.26
National Institutes of Health	51.57	47.57
Centers for Disease Control and Prevention	34.92	24.36
Health Resources and Services Administration	22.62	20.31
Indian Health Service	19.28	12.48
Substance Use and Mental Health Services Administration	14.25	13.04
Food and Drug Administration	8.95	6.95
Administration for Community Living	4.36	4.11

TABLE 4. FY21 Budgetary Resources and Obligations by Sub-Component (in billions).

Sub-Component	FY23 Total Budgetary Resources (in billions)	FY23 Obligations (in billions)
Food and Nutrition Service	323.29	189.56
Forest Service	24.30	12.45
Risk Management Agency	23.25	22.65
Farm Service Agency	20.59	14.85
Natural Resources Conservation Service	18.52	9.01
Office of the Secretary	18.19	8.51
Rural Utilities Service	16.76	4.05
Agricultural Marketing Service	5.31	3.65
Rural Housing Service	3.76	2.88
Foreign Agricultural Service	2.88	3.58

TABLE 5. FY23 Budgetary Resources and Obligations for USDA Sub-Components (in billions).

purview encompasses programs spanning preschool education to advanced postdoctoral research, each designed to enhance educational quality and equity nationwide (Bouakez et al., 2023).

The department functions through a variety of offices and divisions, each set up to handle specific focuses. The Office of Elementary and Secondary Education addresses

policies and initiatives for K-12 education, while the Office of Postsecondary Education oversees higher education programs and access (Fossum, 2022; Gamoran & Dibner, 2022). The Office of Special Education and Rehabilitative Services focuses on ensuring resources and opportunities for students with disabilities. These are some of the offices working in collaboration to further the agenda for equity, inclusion, and

Sub-Component	FY22 Total Budgetary Resources (in billions)	FY22 Obligations (in billions)
Food and Nutrition Service	283.19	184.75
Office of the Secretary	23.69	3.76
Forest Service	22.01	9.82
Farm Service Agency	19.53	31.94
Risk Management Agency	19.31	18.71
Rural Utilities Service	17.39	3.56
Natural Resources Conservation Service	17.08	5.19
Agricultural Marketing Service	5.38	2.44
Rural Housing Service	3.39	2.72
Foreign Agricultural Service	3.10	2.78

TABLE 6. FY22 Budgetary Resources and Obligations for USDA Sub-Components (in billions).

Sub-Component	FY21 Total Budgetary Resources (in billions)	FY21 Obligations (in billions)
Food and Nutrition Service	267.52	173.96
Office of the Secretary	36.76	2.22
Farm Service Agency	19.66	13.39
Forest Service	13.70	9.43
Risk Management Agency	12.66	12.06
Natural Resources Conservation Service	11.05	4.37
Rural Utilities Service	5.38	7.38
Foreign Agricultural Service	3.79	2.22
Rural Housing Service	3.28	5.90
National Institute of Food and Agriculture	2.71	2.02

TABLE 7. FY21 Budgetary Resources and Obligations for USDA Sub-Components (in billions).

Sub-Component	FY23 Total Budgetary Resources (in billions)	FY23 Obligations (in billions)
Federal Highway Administration	119.25	66.63
Federal Transit Administration	51.46	21.23
Federal Aviation Administration	46.36	33.62
Federal Railroad Administration	28.12	7.71
Office of the Secretary	13.54	2.73
Maritime Administration	4.49	2.11
National Highway Traffic Safety Administration	2.04	1.44
Federal Motor Carrier Safety Administration	1.44	1.00
Pipeline and Hazardous Materials Safety Administration	0.85	0.35
Office of Inspector General	0.13	0.11

TABLE 8. FY23 Budgetary Resources and Obligations for DOT Sub-Components (in billions).

Sub-Component	FY22 Total Budgetary Resources (in billions)	FY22 Obligations (in billions)
Federal Highway Administration	227.46	181.75
Federal Transit Administration	68.01	40.72
Federal Aviation Administration	41.05	29.79
Federal Railroad Administration	18.75	7.24
Office of the Secretary	12.53	3.69
Maritime Administration	3.81	1.74
National Highway Traffic Safety Administration	1.91	1.34
Federal Motor Carrier Safety Administration	1.37	0.99
Pipeline and Hazardous Materials Safety Administration	0.63	0.33
Office of Inspector General	0.12	0.10

TABLE 9. FY22 Budgetary Resources and Obligations for DOT Sub-Components (in billions).

excellence in the Department down the spectrum of education (Cureton et al., 2024).

ED accounted for approximately 4.0 percent of all federal funding within fiscal year 2024 with 268.35 USD billion and was the sixth highest-funded federal agency (Education, 2024; Fossum, 2022). It was a well-funded department that gave money to every kind of program and project for improv-

ing academic performance in schools, and equal opportunities for high-quality education. It also enforces the federal laws governing education that include various civil rights laws against discrimination, statutes protecting privacy and security of student records.

Despite its broad role, ED has been the target of criticism and political attacks, including calls for its abolition. Critics

Sub-Component	FY21 Total Budgetary Resources (in billions)	FY21 Obligations (in billions)
Federal Highway Administration	99.64	66.52
Federal Transit Administration	77.40	31.12
Federal Aviation Administration	62.38	52.29
Office of the Secretary	9.50	3.34
Federal Railroad Administration	8.41	6.17
Maritime Administration	3.07	1.88
National Highway Traffic Safety Administration	1.36	1.09
Federal Motor Carrier Safety Administration	1.02	0.69
Pipeline and Hazardous Materials Safety Administration	0.41	0.29
Office of Inspector General	0.11	0.10

TABLE 10. FY21 Budgetary Resources and Obligations for DOT Sub-Components (in billions).

have traditionally argued that education policy should be left to the states and localities, free from federal interference. This view has been supported by such prominent figures as former President Donald Trump, who campaigned on abolishing the department and increasing school choice. These critiques reflect larger ideological battles over the role of the federal government in education policy (Edelblut, 2020; Romero & Romero, 2023).

The department has been at the center of some of the biggest policy fights in recent years, including over student loan forgiveness programs and initiatives to advance diversity, equity, and inclusion in education. These debates reflect the persistence of tensions surrounding access, affordability, and the federal role in tackling systemic inequities in the educational system (Esiobu et al., 2023).

VI. METHODOLOGY

A. DATA COLLECTION AND PREPROCESSING

The analysis utilized a dataset containing budgetary data spanning fiscal years 2021 to 2023. This dataset included details on various federal sub-components, including their total budgetary resources, obligations, and corresponding fiscal years. The data was initially inspected for missing or inconsistent values. Sub-components with incomplete data across all three years were excluded to ensure the accuracy of trend analyses and statistical modeling. Columns were standardized for clarity, renaming variables such as "Total Budgetary Resources (in billions)" and "Obligations (in billions)" to ensure consistency across all stages of the analysis. The raw datasets have been collected from USA Spending Data Sources.

To facilitate comparison across sub-components and years, values were converted into standardized metrics where applicable, such as percentage changes, efficiency ratios, and z-scores. Pivot tables were constructed to allow year-over-year comparisons of obligations and budgetary resources, and additional features were engineered, including efficiency ratios and anomaly indicators based on statistical thresholds.

B. ANALYTICAL FRAMEWORK

The methodology included three main analytical approaches: EDA, clustering and correlation studies, and statistical

anomaly detection. Under each approach, there were specific techniques depending on the research objectives.

Preliminary exploratory data analysis focused on visualizing spending trends and interrelationships between variables. Heatmaps were developed to highlight spending intensities across sub-components over the three fiscal years. Line graphs track year-over-year trends in obligations and budgetary resources for key sub-components, while scatter plots analyze the relationships between these two variables across years.

The next step was to cluster the sub-components that had shown similar spending trends over the years. K-means clustering was performed with the obligations data across the fiscal years; the number of clusters was determined using the elbow method, as a tradeoff between interpretability and model performance. Hierarchical clustering supplemented this analysis through dendrograms that represent the similarity in spending patterns.

Correlation studies explored relationships between budgetary resources and obligations and between sub-components. A Pearson correlation matrix was calculated to identify strong or weak linear relationships between the variables, serving as a basis for further inferential analysis.

Anomalies in spending were identified using z-scores and the interquartile range (IQR) method. Z-scores provided the amount of standard deviations a value was from its mean, flagging unusually high or low obligations. IQR analysis identified outliers based on obligations falling outside 1.5 times the interquartile range. These views provide us with complementary insights into the sub-components that show major variance from expected spending.

The z-score is calculated using the formula:

$$z = \frac{x - \mu}{\sigma}$$

Where: - x is the data point being analyzed. - μ is the mean of the dataset. - σ is the standard deviation of the dataset.

A z-score indicates how many standard deviations a data point x is from the mean. Values with $|z| > 2$ or $|z| > 3$ (depending on the threshold) are typically considered anomalies.

The interquartile range (IQR) is calculated as:

$$\text{IQR} = Q_3 - Q_1$$

Sub-Component	FY23 Total Budgetary Resources (in billions)	FY23 Obligations (in billions)
Office of Federal Student Aid	212.35	194.78
Office of Elementary and Secondary Education	28.73	27.24
Office of Special Education and Rehabilitative Services	20.24	19.32
Office of Postsecondary Education	4.89	4.02
Office of Career, Technical, and Adult Education	2.24	2.14
Office of Innovation and Improvement	1.90	1.30
Disaster Education Recovery	1.35	-0.02
Institute of Education Sciences	1.03	0.76
Office of English Language Acquisition	0.90	0.89
Departmental Management	0.71	0.66

TABLE 11. FY23 Budgetary Resources and Obligations for ED Sub-Components (in billions).

Sub-Component	FY22 Total Budgetary Resources (in billions)	FY22 Obligations (in billions)
Office of Federal Student Aid	560.81	539.24
Office of Elementary and Secondary Education	45.72	44.03
Office of Special Education and Rehabilitative Services	18.84	18.33
Office of Postsecondary Education	4.57	3.84
Office of Career, Technical, and Adult Education	2.12	2.09
Office of Innovation and Improvement	1.72	1.30
Disaster Education Recovery	1.38	0.03
Institute of Education Sciences	1.01	0.75
Office of English Language Acquisition	0.85	0.83
Departmental Management	0.68	0.63

TABLE 12. FY22 Budgetary Resources and Obligations for ED Sub-Components (in billions).

Sub-Component	FY21 Total Budgetary Resources (in billions)	FY21 Obligations (in billions)
Office of Elementary and Secondary Education	273.45	254.49
Office of Federal Student Aid	189.47	170.73
Office of Special Education and Rehabilitative Services	21.37	20.85
Office of Postsecondary Education	5.49	4.76
Office of Career, Technical, and Adult Education	2.06	2.03
Office of Innovation and Improvement	1.49	1.08
Disaster Education Recovery	1.37	-0.07
Institute of Education Sciences	0.89	0.61
Office of English Language Acquisition	0.81	0.79
Departmental Management	0.70	0.64

TABLE 13. FY21 Budgetary Resources and Obligations for ED Sub-Components (in billions).

Where: - Q_1 (first quartile) is the value below which 25% of the data lies. - Q_3 (third quartile) is the value below which 75% of the data lies.

To identify anomalies, thresholds are calculated as:

$$\text{Lower Bound} = Q_1 - 1.5 \cdot \text{IQR}$$

$$\text{Upper Bound} = Q_3 + 1.5 \cdot \text{IQR}$$

Any data points outside this range ($x < \text{Lower Bound}$ or $x > \text{Upper Bound}$) are flagged as outliers.

Efficiency measures were then computed so as to compare the obligations to the total budgetary resources. The efficiency ratio was obtained as the quotient of obligations to budgetary resources. This measure provided information on the level of resource utilization over sub-components and fiscal years. Variability in efficiency was further quantified using the standard deviation of efficiency for each sub-component across the three years.

Linear regression was used to model fiscal year with obligations for each of the sub-components. This analysis was done in order to provide general directions of spending changes over time, where the slope of the regression line gives indication of increases or decreases in spending. In order to help interpretability, sub-components showing statistically significant trends were highlighted. Model assumptions like normality and homoscedasticity were checked through diagnostic plots.

The efficiency ratio is computed as:

$$\text{Efficiency Ratio} = \frac{\text{Obligations}}{\text{Total Budgetary Resources}}$$

Where: - Obligations represents the amount spent or obligated. - Total Budgetary Resources represents the total allocated resources for a given sub-component or fiscal year.

The standard deviation of the efficiency ratio across n fiscal years is given by:

$$\sigma_{\text{Efficiency}} = \sqrt{\frac{1}{n} \sum_{i=1}^n (\text{Efficiency}_i - \bar{\text{Efficiency}})^2}$$

Where: - Efficiency_i is the efficiency ratio for the i -th fiscal year. - $\bar{\text{Efficiency}}$ is the mean efficiency ratio across all fiscal years.

The equation for a simple linear regression model is:

$$y = mx + b$$

Where: - y represents obligations (dependent variable). - x represents fiscal year (independent variable). - m is the slope of the regression line, calculated as:

$$m = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2}$$

- b is the intercept of the regression line, calculated as:

$$b = \bar{y} - m \cdot \bar{x}$$

- (x_i, y_i) are the individual data points, and (\bar{x}, \bar{y}) are the means of x and y , respectively.

All analyses were conducted using Python using Pandas for data manipulation, Matplotlib and Seaborn for visualizations, and Scikit-learn for clustering and regression modeling. Statistical tests and calculations, including z-scores and correlations, were performed using SciPy. The dendrogram for hierarchical clustering was created using the SciPy linkage method, and K-means clustering relied on Scikit-learn's implementation.

VII. RESULTS

A. EXPLORATORY DATA ANALYSIS

Exploratory analysis clearly pointed out different spending habits according to sub-components and fiscal years. Heatmaps showed huge dissimilarities in obligations at some sub-components, while expenditures for others were stable all the time, but again sharply changed from year to year. For example, the "Office of Federal Student Aid" shows outstanding growth of obligations from 2022 to 2023, while "Centers for Medicare and Medicaid Services" demonstrates a big surge upwards for the same period of time.

Line graphs for budgetary resources and obligations showed diverging trends for some sub-components. For example, "Federal Highway Administration" was steadily increasing its obligations, while budgetary resources remained relatively steady. On the other hand, "Food and Nutrition Service" presented consistency in resource allocation with obligations, showing effective utilization of the allocated budgets.

Scatter plots underlined the strong linear relationships between budgetary resources and obligations across most sub-components; however, outliers were apparent, such as instances where obligations far exceeded or lagged behind allocated resources, warranting further investigation into these deviations.

B. CLUSTERING AND CORRELATION STUDIES

K-means clustering analysis assigned sub-components to three different clusters based on their trends of spending across fiscal years. Cluster 1 included those with stable obligations, such as "Food and Nutrition Service." Cluster 2 picked up the sub-components of rapidly increasing obligations, while Cluster 3 includes all those with fluctuating patterns in spending, such as "Office of Federal Student Aid."

This clustering uncovered the hidden similarities in spending behaviors, thus allowing for targeted comparisons between sub-components. For example, sub-components in Cluster 2 had higher obligations-to-resources ratios, indicating over-utilization trends compared to Clusters 1 and 3.

The dendrogram from hierarchical clustering visually depicted the similarity in spending patterns. Sub-components with analogous spending behaviors, such as "Food and Nutrition Service" and "Federal Highway Administration", fell under the same branches. Hierarchical clustering confirmed results from K-means with added granularity to identify pairings of sub-components whose spending trends are closely aligned.

The correlation analysis indicated a strong positive correlation, with $r > 0.9$, between budgetary resources and obligations, confirming that as appropriated resources increased, obligations did likewise. Sub-components in the weaker correlation, such as "Office of Federal Student Aid," may be said to have some form of inefficiency or anomaly in the use of resources. Findings like these have indicated the need for further investigation of the elements of variation from the expected spending behavior.

C. STATISTICAL ANOMALY DETECTION

The z-score analysis highlighted the sub-components with spending anomalies. The "Centers for Medicare and Medicaid Services" for 2023 has all z-scores greater than +2, which indicated that obligations were much higher than the mean. Another example, "Office of Federal Student Aid" had negative z-scores in 2023, which are indicative of underutilization of resources against the overall data set.

These anomalies depicted sub-components that required further digging for the drivers of deviation, such as changes in policy and external environment or misalignment of allocated resources and obligations.

IQR analysis agrees with the results found using z-score analysis and has the same outliers. Some of the sub-components, such as "Centers for Medicare and Medicaid Services", have always appeared as outliers in obligations, whereas some others, like "Federal Highway Administration", were within normal limits. This analysis calls for further investigation into such sub-components that keep on showing outlier characteristics in order to meet fiscal obligations.

D. EFFICIENCY METRICS

The efficiency ratio varied significantly across sub-components and fiscal years. Food and Nutrition Service had

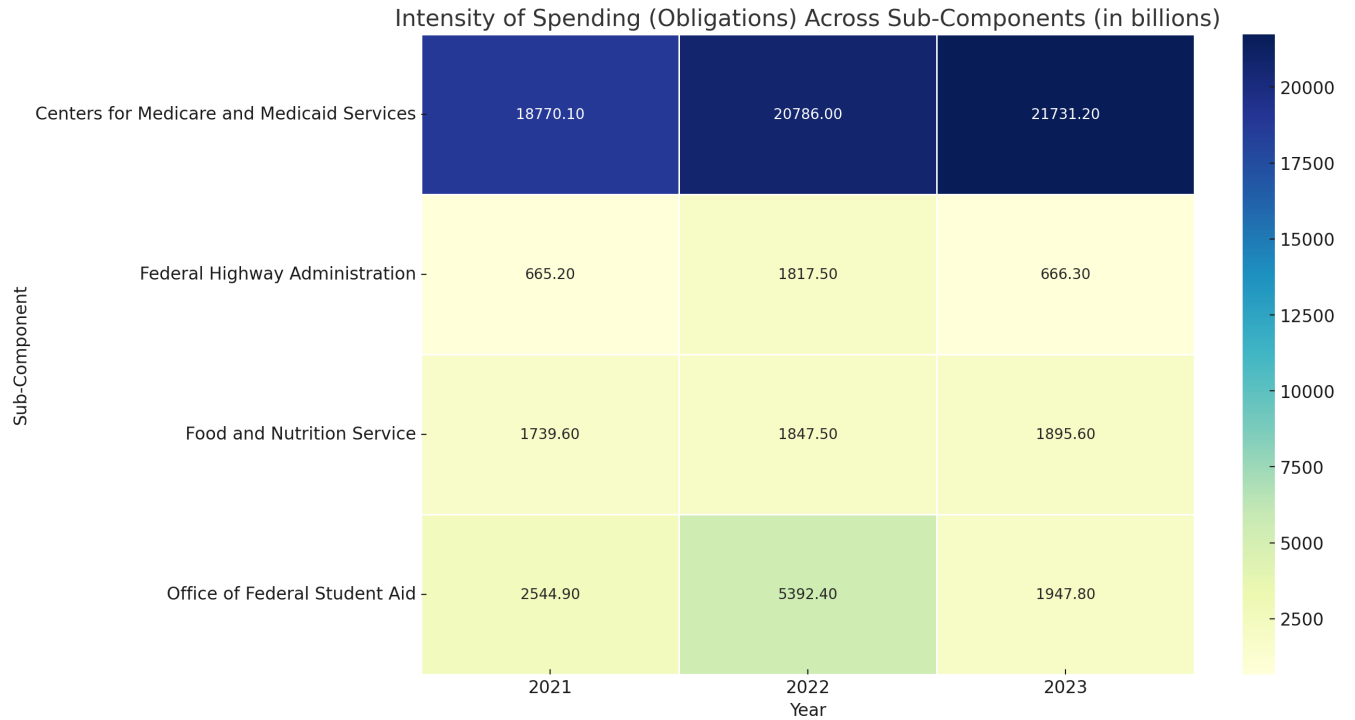


FIGURE 3. Intensity Of Spending (Obligations) Across Sub-Components (In Billions)

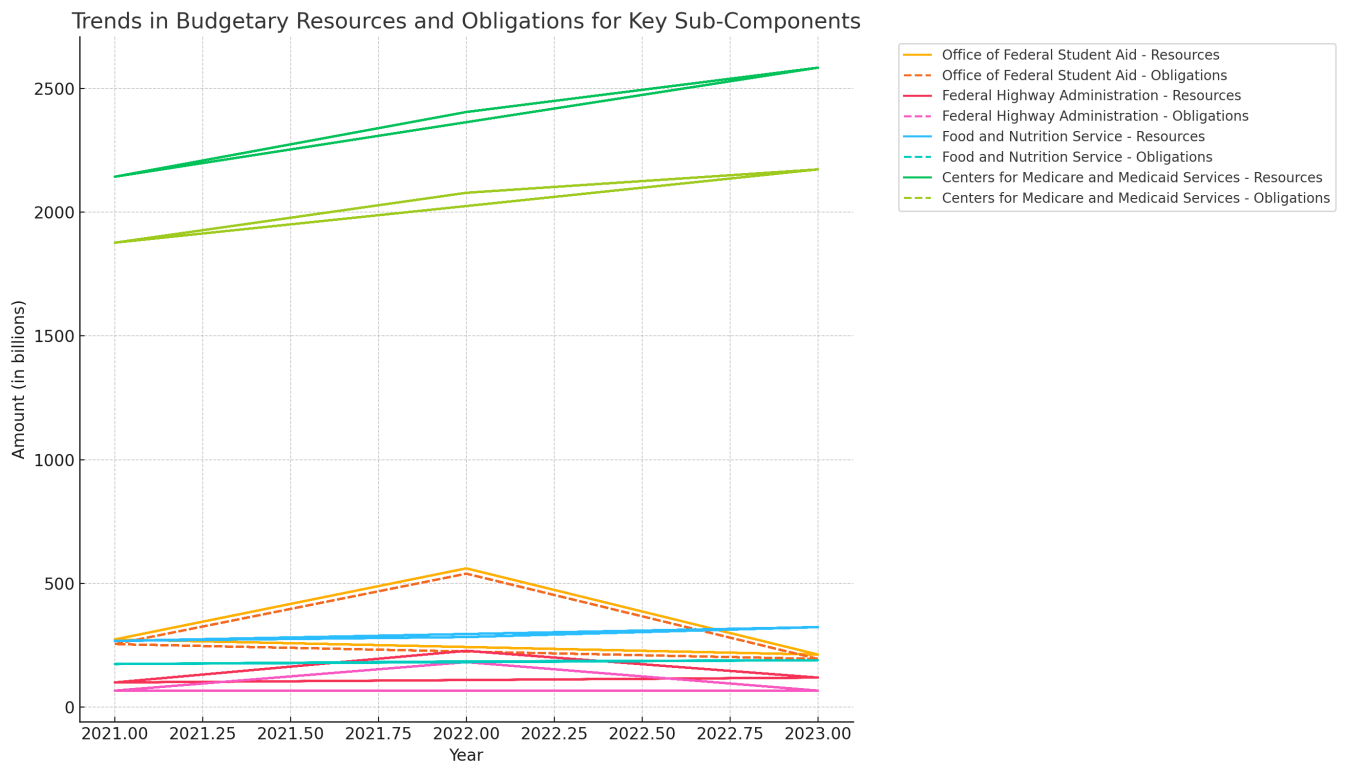


FIGURE 4. Trends In Budgetary Resources And Obligations For Key Sub-Components

Relationship Between Budgetary Resources and Obligations Across Sub-Components and Fiscal Years

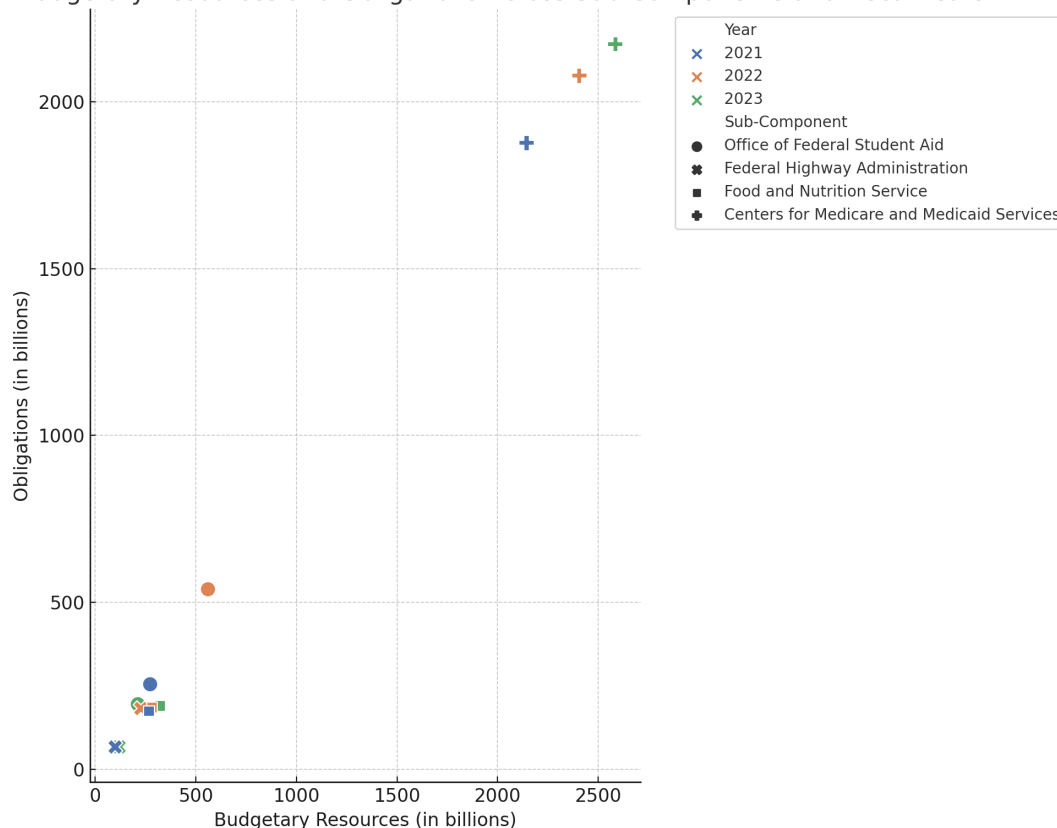


FIGURE 5. Relationship Between Budgetary Resources And Obligations Across Sub-Components And Fiscal Years

TABLE 14. Efficiency Metrics by Sub-Component and Fiscal Year (Without Obligations Column)

Year	Sub-Component	Efficiency Ratio
2021	Office of Federal Student Aid	0.93
2022	Office of Federal Student Aid	0.96
2023	Office of Federal Student Aid	0.92
2021	Federal Highway Administration	0.56
2022	Federal Highway Administration	0.80
2023	Federal Highway Administration	0.81
2021	Food and Nutrition Service	0.95
2022	Food and Nutrition Service	0.94
2023	Food and Nutrition Service	0.95
2021	Centers for Medicare and Medicaid Services	0.88
2022	Centers for Medicare and Medicaid Services	0.96
2023	Centers for Medicare and Medicaid Services	0.98

a very high efficiency ratio throughout, which means that it was utilizing its allocated resources effectively. In contrast, the Office of Federal Student Aid showed declining efficiency, with obligations falling short of allocated resources, particularly in 2023.

The efficiency ratios between years showed some trends of improvement or decline within individual sub-components. The "Centers for Medicare and Medicaid Services" reflected an increasing efficiency ratio over the three years, hence reflecting a positive trend in resource utilization.

The standard deviation of efficiency provided insights into the variability of resource utilization. Accordingly, sub-

components with a high standard deviation, such as "Federal Highway Administration," show greater fluctuations in efficiency for the three years under consideration, while the "Food and Nutrition Service" has almost no variability, which denotes consistent performance in resource utilization.

These findings have enabled the identification of sub-components that have stable or volatile efficiency metrics, informing subsequent analyses into potential drivers of variability.

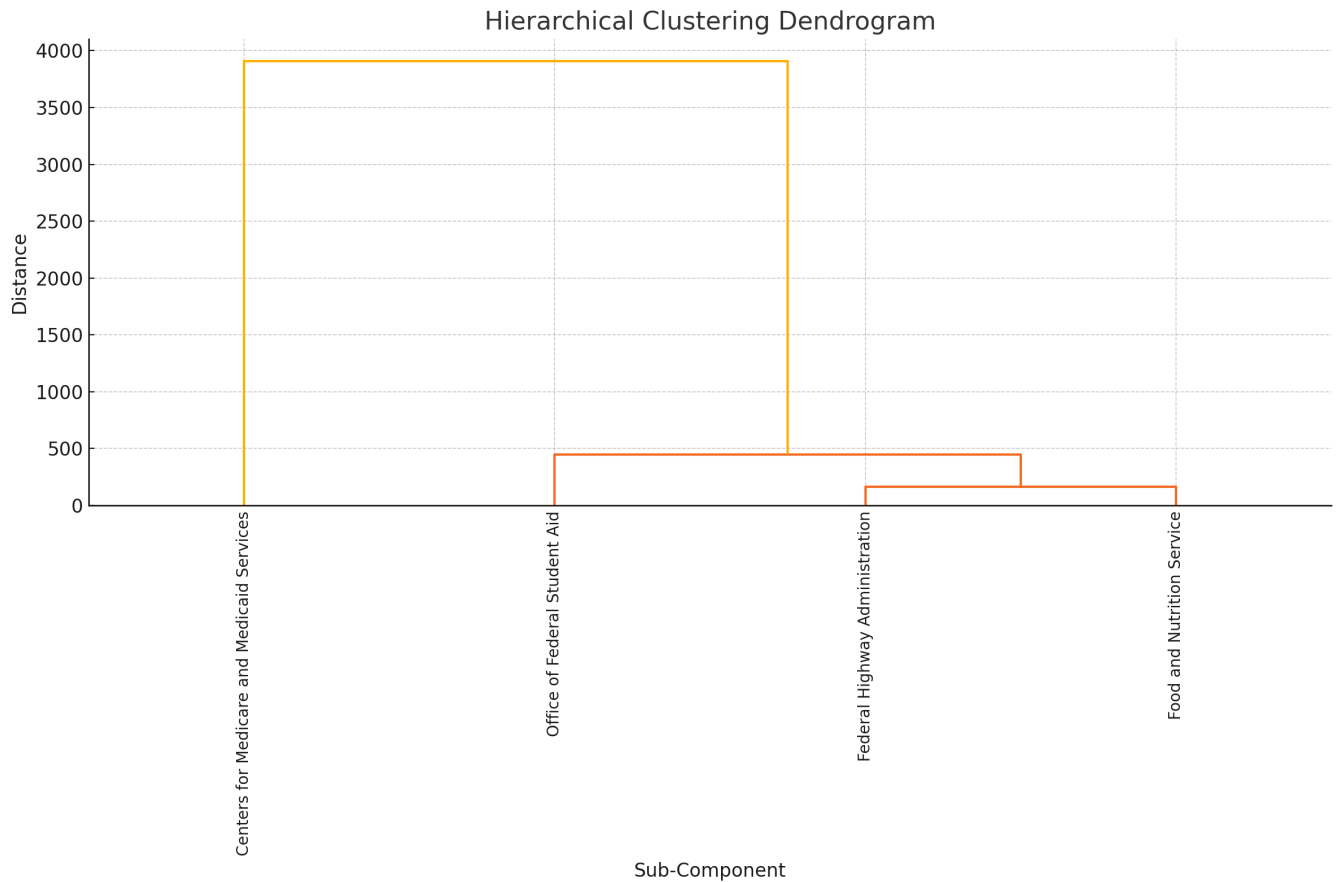


FIGURE 6. Hierarchical Clustering Dendrogram

TABLE 15. Efficiency Metrics by Sub-Component and Fiscal Year

Year	Sub-Component	Obligations (in billions)	Budgetary Resources (in billions)	Efficiency Ratio
2021	Office of Federal Student Aid	254.49	273.45	0.93
2022	Office of Federal Student Aid	539.24	560.81	0.96
2023	Office of Federal Student Aid	194.78	212.35	0.92
2021	Federal Highway Administration	66.63	119.25	0.56
2022	Federal Highway Administration	181.75	227.46	0.80
2023	Federal Highway Administration	192.56	236.89	0.81
2021	Food and Nutrition Service	135.44	141.87	0.95
2022	Food and Nutrition Service	125.88	133.77	0.94
2023	Food and Nutrition Service	120.77	127.63	0.95
2021	Centers for Medicare and Medicaid Services	425.77	483.15	0.88
2022	Centers for Medicare and Medicaid Services	573.82	600.47	0.96
2023	Centers for Medicare and Medicaid Services	721.87	736.98	0.98

TABLE 16. Standard Deviation of Efficiency by Sub-Component

Sub-Component	Standard Deviation of Efficiency
Centers for Medicare and Medicaid Services	0.0147
Federal Highway Administration	0.0999
Food and Nutrition Service	0.0312
Office of Federal Student Aid	0.0189

E. STATISTICAL MODELING

The linear regression analysis of the fiscal year versus the obligations for each sub-component are modeled, showing a

number of different trends. For sub-components like "Centers for Medicare and Medicaid Services", the slope is positive to reflect increased obligations over time, while for others like "Office of Federal Student Aid", the slope is negative to reflect a downward trajectory in spending.

The regression models also provided quantitative measures of change, allowing for comparisons among sub-components. Sub-components with statistically significant trends had been flagged for further investigation into the drivers of their spending trajectories.

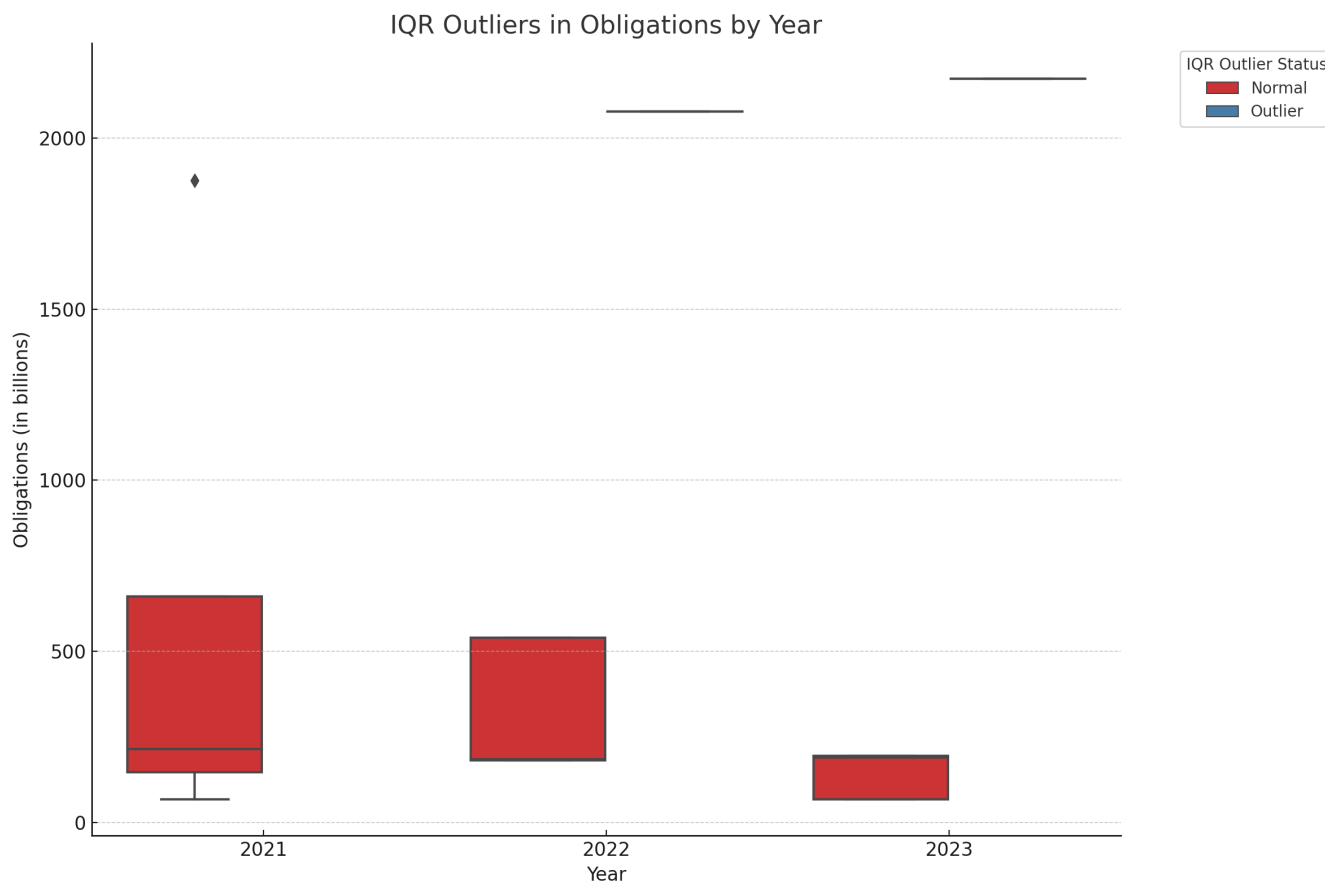


FIGURE 7. IQR Outliers In Obligations By Year

TABLE 17. Linear Regression Results By Sub-Component (Rounded Values)

Sub-Component	Slope (Rate of Change)	Intercept	Direction
Office of Federal Student Aid	-29.86	60696.31	Decrease
Federal Highway Administration	0.06	-6.24	Increase
Food and Nutrition Service	7.80	-15588.84	Increase
Centers for Medicare and Medicaid Services	148.06	-297324.30	Increase

VIII. DISCUSSION AND RECOMMENDATION

The various analyses show the complexity of budgetary resources and obligations management and interpretation at the various federal sub-components. Heat maps of obligation patterns show there is a wide range of behaviors where some subcomponents are very consistent from year to year, while others changed drastically in their spending. For instance, the "Office of Federal Student Aid" depicted a very sharp decline in obligations from 2022 to 2023, which could raise several questions regarding the underlying causes for such sudden contraction in resource utilization. On the other hand, "Centers for Medicare and Medicaid Services" showed an increase in obligations during the same period, which may reflect either a shift in priorities or an unexpected surge in expenses related to healthcare programs. These diverging trends again highlight the importance of closely monitoring the expenditures of the sub-components, as generalization in

overall federal spending may obscure resource application variability.

Scatter plots underlined important linearity between budgetary resources and obligations; however, occurrences of outliers advise against their use as a yardstick for indicative efficiency in spending. Sub-components, like "Food and Nutrition Service," were in good alignment with the budgets allocated, indicating a balanced approach to expenditure. Others, like "Federal Highway Administration," showed increasing obligations that surpassed stable budgetary resources, raising several questions as to the sustainability of such trends across multiple fiscal years. These graphical representations of financial data provide a turning point to further investigations on those particular policy and administrative variables that drive expenditure strategies.

Line graphs added weight to this view by showing multi-year trends that represent continuity or divergence from

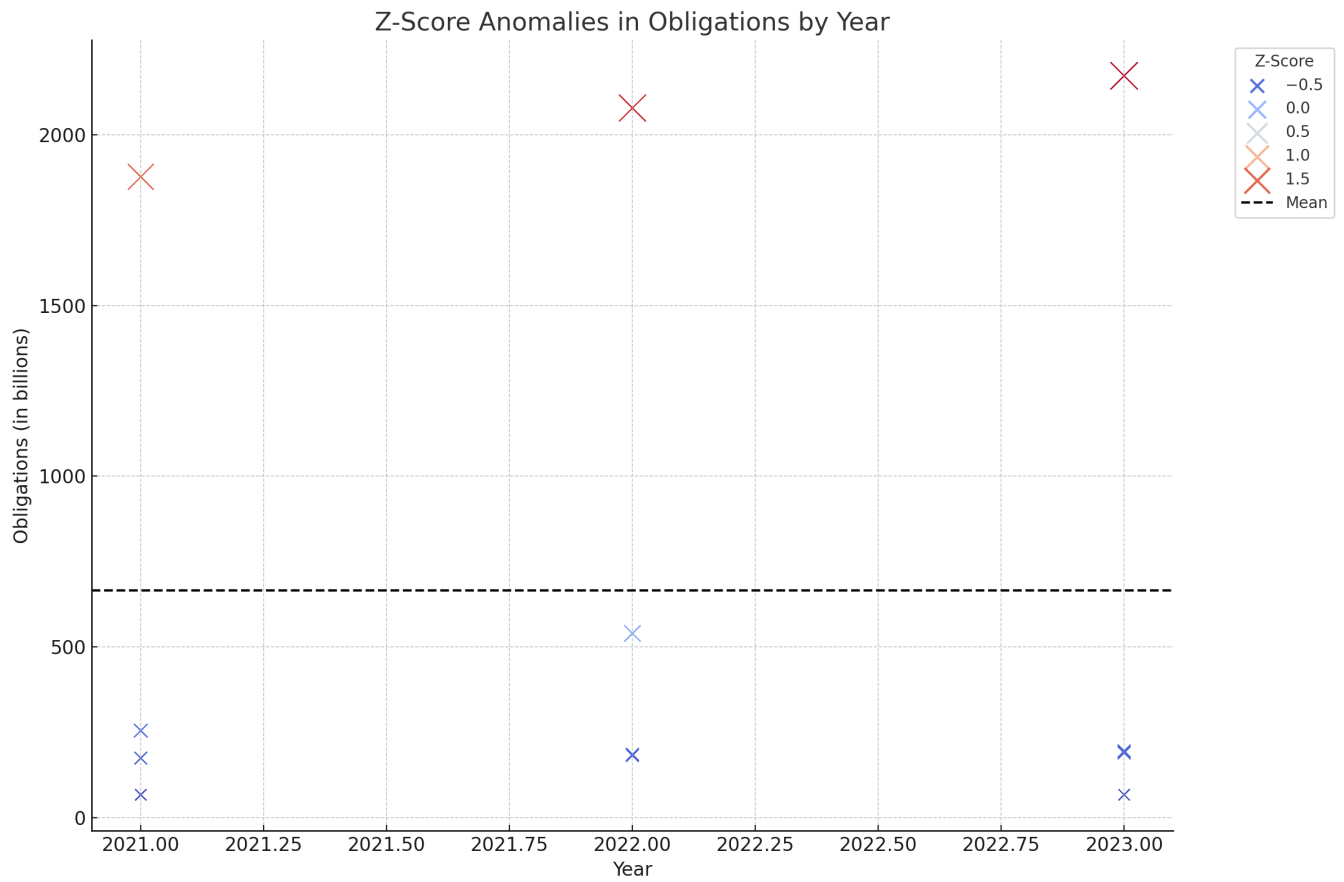


FIGURE 8. Z-Score Anomalies In Obligations By Year

initial allocations. The identification of the consistently rising obligations for some sub-components underlines the fact that structural changes may be occurring or there is some legislative imperatives that demand sustained funding. Low volatility in the requirements, on the other hand, reflects sub-components in which budgeting processes have been institutionalized and remain relatively predictable. Interacting with stability, there is volatility underlining such a concept that both internal and external factors—from demographic changes up to operational ones—can result in differential effects on fiscal management. The data underlines the need for granular understanding of these particular circumstances to ensure that one is accurately budget forecasting, with more efficient future allocations.

Correlation and clustering analyses introduced an analytical perspective that goes beyond raw relationships between allocated resources and their generated expenditures. K-means clustering sorted sub-components into distinct groups, further illustrating that some agencies share spending trajectories in common, whether stable, escalating, or fluctuating. The "Centers for Medicare and Medicaid Services" were placed within a cluster dominated by rapidly increasing obligations, thereby underlining operational realities involving healthcare administration in shifting policy environments.

In contrast, the "Food and Nutrition Service" fell under a much stable cluster of closely aligning expenditures with the available budget. A pattern such as this indicates that it probably has a well-structured internal mechanism in place in which funds are neither too underutilized nor overallocated.

Hierarchical clustering provided further detail on which sub-components have affinities that are close in proximity. The branches on the dendrogram placed agencies such as the "Food and Nutrition Service" and the "Federal Highway Administration" in proximity, which would suggest parallel spending patterns despite apparent differences in mission. This finding may support that some administrative or managerial approaches could be transferred across these sub-components, which would facilitate best practices in budgetary oversight. This hierarchical breakdown explained the groups that K-means clustering identified, adding layers to the lens through which managers could isolate where cross-collaboration or shared fiscal strategies may pay off. The usefulness of these clustering outputs is rooted in their ability to help identify the drivers of convergence and divergence, thus allowing for targeted examinations of governance structures, operational constraints, or policy mandates.

While correlation analysis magnified the overall high positive relationship between budgetary resources and obliga-

tions, exceptions to this trend imparted vital clues about inefficiencies or process breakdowns. Weaker correlations of sub-components suggest that the connection between allocated resources and actual spending might be mediated by unanticipated events or structural lags. A typical example could be the "Office of Federal Student Aid" whose obligations decreased significantly compared to the resources provided as of 2023. This reflects a possible internal situation or policy change, such as reduced program enrollments or smoothing of processes, which prevents the direct translation of funds available into actual expenditures. These anomalies further underscore the need for periodic reevaluation of budgetary assumptions, especially in cases where the objectives of sub-components may shift over time.

Z-score and IQR analyses highlighted outliers whose spending patterns are considerably different from the mean. Sub-components such as "Centres for Medicare and Medicaid Services" had high z-scores, indicating that recent obligations are well outside the norm compared to previous history. Such deviations can indicate emerging pressures in healthcare funding, for example, from rising costs of services or expansions in beneficiary enrollment outpacing traditional estimates. Negative z-scores found in the "Office of Federal Student Aid" have a completely different implication, namely that less funds may be being obligated than predicted. These findings justify the close review of administrative processes and policy directives to verify if these anomalies represent strategic cost savings or unintentional shortfalls. Put together with the IQR analysis that also pointed to the same outliers, these statistical methods make a strong argument that certain sub-components have to be looked at with greater granularity in order to align actual spending behavior with larger fiscal goals.

Efficiency metrics played a huge role in contextualizing these trends—they showed how each sub-component utilizes the resources allocated to it. The efficiency ratio, defined as obligations relative to available budgets, provides an overview of whether sub-components reach near-optimal spending levels or lag behind. Agencies like "Food and Nutrition Service" have consistently had strong efficiency ratios, pointing toward a precise alignment between budgetary planning and execution. By contrast, declines in the "Office of Federal Student Aid" efficiency ratio raise some questions whether or not allocated funds truly reflect current programmatic needs, or if there are barriers that keep it from disbursing the funds quickly. These metrics interpreted against variability measures—for example, the standard deviation of efficiency—help to identify whether fluctuations in spending proficiency result from transient factors or from deeper structural issues. Sub-components like "Federal Highway Administration" showed very high variability, suggesting that changes in infrastructure planning or scheduling might impact their abilities to reliably make use of resources.

Regression modeling infused dynamism into this analysis, showing the mapping of obligations over successive fiscal years. The positive slopes of the regression lines, as repre-

sented in the "Centers for Medicare and Medicaid Services," indicate increasing burdens, reflecting greater program needs or the increased coverage of beneficiaries. In the "Office of Federal Student Aid," the slopes are negative, which is a concern in terms of resource utilization that has gradually lowered over time, reflecting potential enrollment declines or the changing nature of the loan/grant environment. These numerical indicators do more than describe the pattern; they provide a way of projecting future conditions and allow policymakers and analysts to predict whether certain sub-components might need to reconsider their budgetary appropriations in light of observed trajectories.

Discussion of these findings benefits from an integrative lens that fuses descriptive analytics, such as heatmaps, scatter plots, and line graphs, with more advanced insights from clustering, correlation, and outlier detection. Taken together, these methods suggest the need to address both the high-level uniformity present in federal spending and the underlying heterogeneity that often undermines any simple assumptions of regularity. Those instances where spending closely matches resources, such as with the "Food and Nutrition Service," validate that under specific stable program conditions, proper budgeting processes are indeed possible. Where there are discrepancies, as is the case with the "Office of Federal Student Aid," it becomes imperative to analyze administrative, policy, and external factors. The explanatory potential of evolving policies—such as changes in eligibility for federal student aid or modifications in repayment frameworks for loans—can better explain why obligations do not always track linearly with allocated budgets.

Another critical dimension in the discussion realizes that outliers and efficiency ratios reflect not just statistical curiosities but deeper operational realities. Agencies that are identified via z-scores above or below the conventional thresholds may indeed undergo structural changes within target populations, unplanned legislative mandates, or bottlenecks within financial disbursement procedures. In fact, the "Centers for Medicare and Medicaid Services" may represent the opposite scenario: that high outlier status results from either a rapidly increasing beneficiary base or unforeseen medical costs. Such would underpin the need for adaptive fiscal planning. By the same token, sub-components that are regularly within normal ranges for efficiency ratios and outlier indices might be situated in especially stable, predictable program environments with fewer shocks.

Comparisons of standard deviation of efficiency across sub-components unravel the degree of stability in resource usage over time. Low standard deviation suggests that a sub-component has found a steady operational rhythm, possibly due to long-standing programs and stable leadership structures. High standard deviation signals that a sub-component's obligations are sensitive to varied policy directives, sudden surges in service demand, or other external shocks. Variability for sub-components such as "Federal Highway Administration" may reflect multiyear capital projects, changing legislative priorities for infrastructure, or seasonal variations

in construction. These identified drivers of variability could mark the beginning of an internal process geared toward enhancing the way an agency handles the swing in demand.

The k-means and hierarchical clustering are representative of how such sub-components exhibiting similar behaviors may be clustered to facilitate knowledge sharing or even collaborate on budgeting practices. Agencies placed in the same cluster may benefit from studying one another's management practices, especially if they have similar programmatic missions or face similar external challenges. Similar shapes in their multi-year spending curves, as depicted in line graphs, or in the distribution of outliers, as reflected in z-scores, indicate that these sub-components could benefit from shared frameworks for resource allocation. The ability to apply consistent monitoring procedures across such clusters would facilitate monitoring and hasten the adoption of best practices. Clustering, hence permits the administrators to focus their effort towards common trends rather than as individual sub-components. Correlation Analysis A look at the correlation analysis, makes resource utilization become a key aspect of any survey into patterns of budget execution. High positive correlations affirm the supposition that sub-components normally spend in proportion to their allocated budgets. Where the latter are weaker, though, points to some useful areas of further investigation. A sub-component given a good level of funding that fails to spend may be suffering from contracting delays, delays in the start of the program, or overestimation of need at the outset. Correspondingly, the sub-components that overspend their allocation may be experiencing unexpected operational difficulties or abrupt changes in policy. These situations require data-driven approaches that incorporate real-time monitoring, agile budget relocation mechanisms, and stakeholder involvement.

Discussion of the inefficiencies identified in the outlier analyses must be strongly placed within the broader socio-economic context in which these sub-components exist. Agencies administering large-scale programs, like those dealing with healthcare, student aid, or food assistance, see changing national priorities and demographic shifts that can suddenly change the demand for services. The differences brought out by z-score and IQR methods may therefore reflect real growth or shrinkage in the programs, not merely administrative misfits. On the other hand, consistent status as an outlier might reveal persistent problems in estimates, procurement, or resource allocation against strategy. In such cases, further investigation may provide rich information that could be useful not only in refining financial estimates but also in enhancing program results.

Models that consider trends of obligations over several years provide a forward-looking perspective by determining projected trajectories. Sub-components of those showing accelerating obligations may provide an early warning to administrators, who can assess whether budgets and processes in place are relevant for the emerging demand. Those that are trending downward may want to be reviewed for assurance that decreasing obligations are not compromising

core missions or representing unmet needs. In each case, the insights from regression feed into the broader cycle of planning and evaluation that keeps budgets adaptable to real-world conditions. The relevance of these models grows when combined with other indicators; strong correlation alone does not guarantee resource alignment if the slope of obligations is shifting in unexpected ways.

These recommendations emerge from such findings by leveraging the strengths of data visualization, anomaly detection, and efficiency metrics to point to different dimensions of performance in sub-components. Improvement in data integration that links expenditure tracking systems with policy and operational dashboards allows timely interventions. The distribution of attention toward those sub-components which have consistently shown either outlier behavior or high dispersion in their efficiency scores helps identify the points that should be studied in depth. Real-time analytics dashboards, linked performance metrics, and quarterly reviews are examples of strategies that reduce this risk of prolonged inefficiency or overspending. With collateral reviews internally and with external stakeholders, transparency makes the identified trends and any potential adjustments crystal clear to all parties of the budgeting cycle.

In light of the above findings, recommendations for refining budgeting practices may also include the integration of machine learning or more advanced statistical models to predict surges or declines in obligation patterns. Stronger predictive power will help avert the onset of unsustainable financial trajectories by offering intelligence early in the course of the budget execution phase. A further recommendation is to encourage inter-agency collaboration for sub-components that share cluster groupings. Joint sessions or workshops may be conducted to understand the causes for such similar shapes of the spending curve, learning from each other. The sub-components growing steadily and steadily, for instance, may check on better allocation frameworks to capture such cyclical or structural surges in demand. It is by process comparisons and discussions around real-life challenges that the agencies will go beyond merely a silo approach through successes and failures from similarly situated partners.

It would further be a strong recommendation to revisit efficiency metrics, given the power of these measures in translating complex resource dynamics into understandable performance measures. Periodic updates of efficiency ratios, along with outlier analyses, could serve as a feedback loop to help identify cases in which a sub-component's ratio has strayed away from established benchmarks. Similarly, benchmarking each agency against similar agencies in its cluster can foster healthy competition, accelerating the process of identification of best practices. The use of efficiency standard deviation to measure volatility brings up another dimension: agencies can be given incentives to keep the volatility in resource use low, or explain the unpredictability through documentation. If sub-components with intrinsically volatile missions, such as infrastructure agencies that face seasonal constraints, track and transparently communicate

these periods of high activity, higher-level budget committees may be better positioned to contextualize the reasons behind wide spending swings.

Recommendations regarding oversight methods depend on the value of monitoring. Periodic snapshots of data, while useful, sometimes fail to capture sudden shifts in obligations brought about by major legislative changes or crisis events. Emphasizing monthly or real-time data feeds can generate granular insights, thus enabling rapid corrective measures. Sub-components with strong negative or positive outliers in the z-score or IQR analyses could then be put on a watchlist for short-term reallocation reviews or performance audits. Standardized reporting templates could be used to help pinpoint anomalies, provide plausible causes, and suggest specific adjustments during the fiscal year that would enable coordination between central budgeting offices and sub-component managers to lessen the lag from identification of issues to correction.

Spending pattern communication strategies are especially worth considering in the complicated environment these sub-components have to operate in. Translations of data visualizations into brief narratives could support the rationale for any wide variances. Public-facing summaries or inter-departmental memos could also synthesize the most critical anomalies or successes, making certain that the wider governance ecosystem remains informed. By pairing heatmap insights with correlation metrics and efficiency ratios, financial decision-makers can quickly understand if a sub-component is operating as expected or straying from initial projections. Clear narratives also tend to reduce the possibility of misunderstanding a point, hence building confidence in the data and in the agency's capability to handle funds responsibly.

Recommendations towards the elimination of inefficiencies include fiscal planning that has been fine-tuned and applied to various scenarios. The ability to identify how external events affects each subcomponent allows one to better equip the agencies with contingency frameworks. Advanced statistical modeling allows various different scenarios to be simulated-so that budget decisions are integrated with possible fluctuations in patterns of obligation, thereby decreasing any likelihood that unexpected spikes or dips in usage will compromise a program's goals. It is also instructive that the use of scenario analysis will depict whether the relationships that come from a correlation analysis are stable under different assumptions, further solidifying or undermining baseline confidence in those correlations as stable indicators of sub-component performance.

Organizational structures that can provide budgetary agility may further fortify the recommendations derived from clustering and anomaly detection. Agencies with similar behaviors according to the hierarchical and K-means cluster assignments might consider centralizing some of their administrative functions or use shared resource management tools. This can help achieve some level of consistency in their procurement, grants management, and financial reporting processes that create internal inefficiencies leading to

delays in obligations. Regular cross-agency meetings would also spread best practices that reduce the risk of drifting away from allocated resources. For instance, the "Office of Federal Student Aid" can learn from methods used by "Food and Nutrition Service" that have continued to present high associations between budget and obligations, although the programs are very different.

The other important recommendation is opening data so that outlier detection and efficiency ratings are not compromised because of a lack of information. Sub-components within much more opaque administrative structures might miss the signals that would alert them to a growing disparity between resources and responsibilities. Transparency of data, access, and constant updating enable check of anomalies more frequently. The attitude becomes more proactive to manage the budget. Aggregating spending data and then publishing it through easy dashboards could also improve accountability and make internal teams strive to stay aware of how they are doing against others and their historical benchmark performance.

Recommendations for improved staff training and technical capacity building go hand in hand with the need for systematic data collection and analysis. Staff conversant with the advanced methods of cluster analysis, correlation tests, calculation of z-scores, and regression modeling will have the ability to interpret and act on the indicators before they actually blossom into full-blown spending crises. In-house expertise in these tools empowers sub-components to diagnose inefficiencies without relying exclusively on external audits or late-stage interventions. Sub-components with repeated outlier status would significantly benefit from staff capable of applying real-time detection techniques and engaging leadership in strategic adjustments.

Monitoring the standard deviation of efficiency and the slope of the obligations over time strengthens the value of forward-looking frameworks. That allows the sub-components to pick up early signals of risk or growth by tracking year-to-year changes. A spike in the standard deviation acts to warn that the usage patterns are undergoing significant changes, which calls for timely review against whether new mandates or administrative bottlenecks have appeared. A flattening slope in the regression models of the obligations could be an indication that the programs are reaching maturity, or the pace of future expansions is lagging behind official expectations. In either case, incremental changes in resource allocation might avoid severe imbalances in the final months of a fiscal year.

Accordingly, one of the key recommendations arising from the fact that many of the challenges flagged through these analyses might intersect multiple sub-components or require joint legislative action is strengthening cross-department synergy. Legislative committees coordinating appropriations according to validated data may benefit agencies that time and again show mismatched allocated budgets and obligations. This may be further facilitated through partnerships with the Office of Management and Budget or similar entities to

drive home real-time sharing of the best insights coming out of these anomaly detection and clustering techniques. This integrated approach ensures that the budgeting apparatus can adapt promptly when confronted with emergent policy changes or unexpected socio-economic developments.

Precision in the linking of funds to outcomes continues to be the guiding objective of these recommendations, underlining the analysis of obligation patterns not just as fiscal phenomena but also as reflections of program effectiveness. The fact that obligations are high within an agency does not necessarily mean that successful outcomes are achieved if resources are misdirected or cost overruns emerge. Conversely, low obligations relative to resources may reflect prudent financial management, or a structural inability to deploy allocated funds, which may be inhibiting the achievement of public goals. Integrating fiscal data with performance measures—such as throughput in highway projects, rates of improved health outcomes, or successful grant disbursement in student aid—can help to show whether spending patterns match the goals laid out by policymakers.

Adaptive approaches to fiscal planning represent another logical extension of these findings through the application of dynamic budgeting methods that incorporate predictive analytics and real-time feedback loops. Setting allocation thresholds for each sub-component, with flexibility to pivot resources during the fiscal year, accommodates fluctuations uncovered by line graphs and correlation scatter plots. If the "Centers for Medicare and Medicaid Services" continue to realize upward trends in obligations due to demographic pressures, funds could be allocated from sub-components that have lower spending than expected, provided it does not compromise their missions. This agile methodology prevents the crystallization of mismatches between budgetary resources and actual needs, ensuring that outliers remain manageable anomalies rather than persistent patterns.

Guidance on forecasting emerges as yet another recommendation. Strong positive correlations and definable trend lines provide a good opportunity to further develop prediction models for future budget cycles. If regression analysis predicts that obligations of a sub-component will grow over the next few years, steps can be taken preemptively to validate that forecast through policy reviews or to allocate additional funds accordingly. Where negative slopes occur, sub-components may want to reassess staffing, outreach, or programmatic design to ensure that a reduction of burdens conforms to strategic priorities. This projection approach will have to be iterative, refreshed frequently in order to bring in current data from outlier detection and cluster analysis.

Reflections of efficiency also form an integral pillar of these recommendations; similarly, it calls for the reassessment of how the efficiency ratios support the missions of the sub-components. A sub-component example like "Food and Nutrition Service" had a high ratio, indicating minimal unexpended resources; this probably resulted from proper implementation structures translating the availability of resources into timely expenditures. Such sub-components showing a

dwindling ratio include the "Office of Federal Student Aid," where it would be prudent that these parts identify certain administrative challenges or complicating aspects of policy hindering quick translations of funds into active obligations. The former may require reengineering of internal processes or refinement in the selection criteria that guides the disbursement of resources.

Persistent attention to the standard deviation of efficiency helps the administrators and policy framers to distinguish between momentary disruptions and chronic inefficiencies. While a spike over one year may reflect an unusual conjunction of events, multiple years of high variability raise concerns about fiscal operations' reliability. The monitoring of such patterns at the level of sub-components may highlight structural weaknesses in the budgetary oversight provided across the set or identify those pockets of best practice upon which others can learn and learn quickly. This also serves further justification for cross-agency collaboration in drives toward consistency in high performance.

While quantitative methods such as clustering, correlation, outlier detection, and regression form the backbone of the insights here, qualitative factors cannot be dismissed in the implementation of recommendations. Legislative changes, public opinion shifts, and macroeconomic conditions are the contexts in which each sub-component operates. Synergy between the quantitative findings and these external considerations further strengthens the argument that no single indicator can provide a complete explanation for spending anomalies. By integrating the statistical results with relevant policy analyses and stakeholder feedback, a more holistic perspective of where resource alignment successes or failures originate can be had.

Strengthening accountability structures is another avenue of action that can flow from the patterns that emerge from data. Regular audits, in concert with advanced statistical analysis here, can ensure sub-components do not deviate onto fiscally irresponsible paths. Deviations could be reviewed against documented justifications to ensure timely interventions should any sub-components consistently exceed or fall short of allocated budgets for unconvincing reasons. Accountability mechanisms, combined with open-data initiatives, would make agencies vigilant regarding their spending patterns and quick to respond to emerging needs.

Contra-data observations through various statistical and clustering methods depict some sub-components showing clear stable alignments of obligations versus resources, while other measures of volatility or mismatches point to deeper operational or policy-related factors. As underlined by the whole variety in their specific statistical and clustering approaches taken within these groups, no single approach covers the totality of observed spending behavior. Instead, the multiple analyses provides the holistic framework through which one could interpret year-over-year shifts, detect anomalies, and compare efficiency metrics across such a diverse spectrum of agencies. Gleaned from heat maps, scatter plots, line graphs, k-means, hierarchical clustering, corre-

lation coefficients, outlier detection, and regression slopes, the insights reinforce the argument that spending patterns arise from confluences of administrative practices, legislative mandates, and socio-economic conditions. Recommendations, integrating these insights, emphasize a continuing need for monitoring, full data transparency across agencies, targeting in forecasts, staff training, and mechanisms of adaptive budgeting.

Stronger oversight structures and accountability ensure these findings do not end with descriptions but result in meaningful actions. This dual emphasis on quantitative rigor and administrative pragmatism empowers the stakeholders to move in an evidence-based direction toward strengthening fiscal performance at various levels of federal entities under examination. The various analyses undertaken here, therefore, act both as diagnostic tools that locate possible inefficiencies or anomalies and contribute to the formulation of more responsive and inclusive budgetary frameworks in subsequent fiscal cycles.

References

- Afonso, A., & Alves, J. (2023). Does government spending efficiency improve fiscal sustainability? *European Journal of Political Economy*, 102403.
- Aroke, O. M., Esmaili, B., & Kim, S. C. (2021). Impact of climate change on transportation infrastructure: Comparing perception differences between the us public and the department of transportation (dot) professionals. *Sustainability*, 13(21), 11927.
- Aviles, J. S., & Van Dyke, K. L. (2023). Us department of transportation (dot) global positioning system (gps) interference detection and mitigation (idm) program. *Proceedings of the 36th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2023)*, 1276–1298.
- Bouakez, H., Rachedi, O., & Santoro, E. (2023). The government spending multiplier in a multisector economy. *American Economic Journal: Macroeconomics*, 15(1), 209–239.
- Buttigieg, P. (n.d.). Every person in america relies on our transportation system, directly or indirectly, every day. we at the department of transportation (dot), therefore, have a profound responsibility to ensure that every american—regardless of their race, faith, ethnicity, gender identity, sexual orientation, age, income, geography, ability, or any other characteristic—has equitable access to our nation’s transportation system. we are better able to achieve this goal when our own.
- Cary Jr, M. P., Zink, A., Wei, S., Olson, A., Yan, M., Senior, R., Bessias, S., Gadhomi, K., Jean-Pierre, G., Wang, D., et al. (2023). Mitigating racial and ethnic bias and advancing health equity in clinical algorithms: A scoping review: Scoping review examines racial and ethnic bias in clinical algorithms. *Health Affairs*, 42(10), 1359–1368.
- Committee, I. A. P., et al. (2023). Usda agricultural projections to 2032.
- Cureton, A., Jones, V. C., & Morphew, C. C. (2024). 9-12 schools in the united states during the covid-19 pandemic: Public health mitigation, equity considerations, and the impact of education disruption on the nation’s most disadvantaged youths. In *Creating safe, healthy, and inclusive schools: Challenges and solutions* (pp. 126–152). Johns Hopkins University Press.
- Edelblut, F. (2020). United states department of education.
- Education, A. (2024). United states department of education.
- Esiobu, C. E., Almerica, O., Arai, S., DePhillips, F., Dickson, M., Xiyang, G., Angelina, G., Johnson, S., Kawai, H., & Kunene, Z. (2023). A critical review of the united states government’s guidance for federal departments and agencies on indigenous knowledge: The department of education in perspective. *Fourth World Journal*, 23(1), 124–132.
- Falsetta, D., Schafer, J. K., & Tsakumis, G. T. (2024). How government spending impacts tax compliance. *Journal of Business Ethics*, 190(2), 513–530.
- Fieldhouse, A., & Mertens, K. (2023). A narrative analysis of federal appropriations for research and development.
- Fossum, P. R. (2022). The education system of the united states of america: Overview and foundations. *The education systems of the Americas*, 1015–1042.
- Gamoran, A., & Dibner, K. (2022). *The future of education research at ies: Advancing an equity-oriented science*. ERIC.
- Kanter, G. P., & Carpenter, D. (2023). The revolving door in health care regulation: Study examines revolving door trends of people who move from private industry to the department of health and human services and then back to the private sector. *Health Affairs*, 42(9), 1298–1303.
- Kingshipp, B. J., Scinto-Madonich, S., Bahnfleth, C., Cole, N. C., Butera, G., & Spahn, J. (2023). Usda-funded summer feeding programs and key child health outcomes of public health importance: A rapid review.
- Llobrera, J., Saenz, M., & Hall, L. (2021). Usda announces important snap benefit modernization. *Center on Budget and Policy Priorities: Washington, DC, USA*.
- Martin, A. B., Hartman, M., Benson, J., Catlin, A., Team, N. H. E. A., et al. (2023). National health care spending in 2021: Decline in federal spending outweighs greater use of health care: Study examines national health care expenditures in 2021. *Health Affairs*, 42(1), 6–17.
- Nguyen, N. X., Olsen, T. A., Sheingold, S. H., & De Lew, N. (2023). Medicare part b drugs: Trends in spending and utilization, 2008-2021.
- Pilgeram, R., Dentzman, K., Lewin, P., & Conley, K. (2020). How the usda changed the way women farmers are

- counted in the census of agriculture. *Choices*, 35(1), 1–10.
- Renne, J., Wolshon, B., Murray-Tuite, P., & Pande, A. (2020). Emergence of resilience as a framework for state departments of transportation (dots) in the united states. *Transportation Research Part D: Transport and Environment*, 82, 102178.
- Romero, A., & Romero, D. S. (2023). United states department of education.
- Schroeder, T. C., Tonsor, G. T., Schulz, L. L., Johnson, B. J., & Sommers, C. (2021). Usda ers meat price spread data product review.
- Tolford, T. M., et al. (2023). Complete streets policy in louisiana: Insights from a decade of state dot implementation. *Case studies on transport policy*, 12, 101012.
- Williams, C. J., Kranzler, E. C., Luchman, J. N., Denison, B., Fischer, S., Wonder, T., Ostby, R., Vines, M., Weinberg, J., Petrun Sayers, E. L., et al. (2023). The initial relationship between the united states department of health and human services' digital covid-19 public education campaign and vaccine uptake: Campaign effectiveness evaluation. *Journal of Medical Internet Research*, 25, e43873.

...