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A System Dynamics Approach to Public Budgeting Reform: Simulating Fiscal Resilience in Iraq

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ABSTRACT

This study aimed to develop and validate a System Dynamics model of Iraq's public budgeting system and evaluate the effectiveness of alternative fiscal reforms in strengthening fiscal resilience under institutional constraints and external economic shocks. An applied, causal-explanatory, mixed-methods design was employed, integrating longitudinal fiscal and institutional data from 2010 to 2023 with qualitative insights from 20 purposively selected experts. Econometric estimation, causal loop diagrams, and stock-and-flow modeling using Vensim were employed to identify feedback mechanisms, validate the simulation model, and assess alternative fiscal reform scenarios. The findings revealed that oil revenues accounted for an average of 82.64% of Iraq's government revenue, while recurrent expenditures represented 73.54% of total expenditure, indicating substantial revenue concentration and expenditure rigidity. The econometric model explained 78.4% of the variation in fiscal performance ($R^2 = 0.784$, $p < 0.001$). Government expenditure exhibited the strongest negative standardized effect ($\beta = -0.527$), whereas oil revenue ($\beta = 0.481$) and institutional capacity ($\beta = 0.294$) positively influenced fiscal performance. The System Dynamics model reproduced 91.4% of historical fiscal behavior, demonstrating satisfactory simulation accuracy. Scenario analysis indicated that a 25% oil-revenue shock without reform reduced the fiscal resilience index to 23.5 and extended recovery beyond ten years. Conversely, an integrated reform package combining expenditure efficiency, institutional strengthening, anti-leakage measures, non-oil revenue diversification, and fiscal stabilization increased the resilience index from 41.8 under the baseline scenario to 84.6, reduced fiscal recovery time from 6.2 to 1.8 years, and generated an average budget surplus of 0.6% of GDP. The study concludes that Iraq's fiscal resilience depends on coordinated structural and institutional reforms rather than isolated fiscal adjustments. The findings highlight the value of System Dynamics modeling as a decision-support instrument for designing adaptive, sustainable, and shock-resistant public budgeting policies.

Keywords: System Dynamics; Public Budgeting Reform; Fiscal Resilience; Oil Revenue Dependence; Institutional Capacity; Fiscal Policy; Iraq.

Introduction

Public budgeting is one of the principal institutional mechanisms through which governments translate political priorities, development strategies, and social commitments into concrete allocations of financial resources. Its effectiveness depends not only on the technical accuracy of revenue and expenditure estimates, but also on the interaction among fiscal rules, administrative capacity, accounting systems, information infrastructures, political



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incentives, institutional quality, and mechanisms of accountability. Contemporary research increasingly treats budgeting as more than an annual accounting exercise, emphasizing its relationship with performance measurement, organizational readiness, financial process optimization, and long-term fiscal sustainability. Performance-based budgeting, for example, seeks to connect expenditure allocations with measurable outputs and outcomes, thereby shifting attention from the amount of money spent toward the value created through public expenditure (1, 2). Similarly, research on the establishment of timely performance-based budgeting systems has emphasized the importance of organizational, informational, managerial, and institutional prerequisites for effective implementation (3). Organizational readiness is therefore a critical condition for budget reform because the introduction of more sophisticated budgeting mechanisms requires appropriate administrative structures, professional capabilities, data systems, and managerial commitment rather than merely formal changes in budget regulations (4). Recent efforts to optimize public-sector financial processes likewise demonstrate that the effectiveness of budgeting is closely connected to the quality and integration of underlying financial procedures, controls, and decision-support systems (5). These developments indicate that modern public budgeting should be understood as a dynamic governance system in which fiscal resources, institutions, administrative processes, and policy objectives continually influence one another.

The need for a more systemic approach becomes particularly important in states characterized by macroeconomic volatility, dependence on concentrated revenue sources, institutional fragility, and recurring fiscal shocks. Fiscal resilience has consequently emerged as an important concept in public administration and fiscal management. Rather than defining sound fiscal policy exclusively in terms of balanced budgets or low debt at a particular point in time, the resilience perspective emphasizes the capacity of a government to resist shocks, recover from periods of fiscal stress, and renew its fiscal and institutional arrangements after disruption (6). This perspective is particularly valuable because adverse fiscal events rarely operate as isolated shocks. Revenue contractions can trigger expenditure compression, borrowing requirements, delayed investment, deterioration of service delivery, political pressures, and institutional responses that may themselves influence future revenues and expenditures. The challenge is therefore not simply to estimate the immediate effect of a shock, but to understand how the fiscal system evolves after the shock and whether policy responses create stabilizing or destabilizing feedback. Comparative work on fiscal rules further suggests that fiscal outcomes cannot be understood independently of governance arrangements and regional institutional conditions, because similar fiscal rules may function differently across political and administrative settings (7). In addition, the growing emphasis on resilient public systems demonstrates that fiscal sustainability requires governments to create sufficient adaptive capacity to finance essential services even when resources are constrained (8). These considerations reinforce the need for analytical approaches that can represent fiscal adaptation over time rather than relying exclusively on static indicators.

Budget credibility represents another important dimension of fiscal resilience. When actual revenues and expenditures differ systematically from approved budget estimates, the budget loses part of its function as a reliable instrument of planning, coordination, and accountability. Research in developing-country contexts has shown the importance of fiscal transparency and forecasting quality for budget credibility, indicating that credible fiscal planning depends on access to reliable information and realistic expectations regarding available resources (9). Forecasting is particularly important when expenditure decisions extend beyond a single fiscal year. Multi-year expenditure forecasting has therefore become an important instrument for anticipating future spending obligations, assessing the sustainability of current commitments, and identifying emerging fiscal pressures before they become acute (10).

This temporal dimension of budgeting is especially relevant in systems where current expenditure decisions create long-term obligations. Public employment, subsidies, pensions, infrastructure maintenance, and other recurrent commitments can generate fiscal persistence, meaning that a temporary revenue expansion may lead to expenditure levels that remain difficult to reverse after revenues fall. Off-budget operations can further complicate fiscal management by weakening the correspondence between formally approved budgets and the government's broader fiscal position, particularly where fiscal dominance and indirect financing channels connect public finances with the banking system (11). Consequently, an assessment of fiscal resilience requires attention not only to the annual budget balance but also to the accumulation of commitments, the persistence of expenditure behavior, and the channels through which fiscal pressures may be transferred across different parts of the public financial system.

The quality of public budgeting also depends on the accounting, reporting, auditing, and information systems through which fiscal decisions are recorded, evaluated, and monitored. Public-sector reforms involving accrual accounting and reporting have sought to broaden the informational basis of governmental decision-making by improving recognition of assets, liabilities, costs, and longer-term financial consequences (12). In similar fashion, accrual budgeting models have been proposed as mechanisms for improving the quality of resource allocation and providing a more comprehensive representation of the financial consequences of public-sector activities (13). The increasing importance of digital transformation further extends this agenda because modern public financial management increasingly depends on integrated data infrastructures capable of connecting accounting, budgeting, service provision, monitoring, and decision-making. Research on financial management information systems has highlighted the significance of alignment between back-end administrative systems and front-end public services, suggesting that the configuration of financial information infrastructures can influence the effectiveness of public-sector operations (14). Digital transformation also creates new accounting challenges, particularly regarding the treatment and management of intangible assets in public organizations (15). At the same time, information technology is reshaping public-sector auditing, with e-auditing and IT governance mechanisms being examined as instruments for reducing audit risk and improving assurance over public financial processes (16). These developments are increasingly accompanied by interest in the adoption of artificial intelligence by public-sector auditors, although such adoption depends on organizational, technological, and institutional propensity factors rather than technology alone (17). Taken together, these streams of research demonstrate that fiscal reform is inseparable from the information architecture and control environment within which budgeting operates.

Performance measurement constitutes an additional component of contemporary budgeting reform. Governments are increasingly expected to demonstrate not only compliance with expenditure authorizations but also the effectiveness and efficiency of public programs. Performance-based budgeting provides one mechanism for establishing this connection, while multidimensional evaluation frameworks can supplement conventional financial measures by incorporating operational and strategic indicators. The integration of budgeting with Balanced Scorecard approaches and multicriteria decision methods, for example, reflects a broader effort to assess organizational performance across multiple dimensions rather than relying on financial indicators alone (18). The Balanced Scorecard literature in government entities similarly illustrates the continuing search for frameworks capable of linking strategic objectives, public value, operational performance, and financial management (19). Such integration is particularly important because public budgeting involves competing objectives. Governments must simultaneously maintain fiscal discipline, provide essential services, invest in development, respond to political demands, and preserve sufficient flexibility to manage future shocks. Operational budgeting research also shows

that the perception and use of budgetary resources are closely connected to institutional expectations regarding service provision, affordability, and organizational operations (20). Accordingly, performance-oriented budgeting cannot be reduced to a technical formula for allocating money; it must be embedded in a broader institutional architecture that connects resource allocation with strategic goals, administrative responsibility, monitoring, and corrective action.

These challenges are especially significant for Iraq because its public finances are structurally exposed to oil-market conditions. A fiscal system in which a large proportion of government revenue is derived from petroleum resources is inherently sensitive to fluctuations in international energy prices, production volumes, and geopolitical conditions. During periods of high oil revenue, increased fiscal space can support expansion in government expenditure, public employment, investment, transfers, and other budgetary commitments. However, if temporary revenue increases become embedded in permanent or difficult-to-reverse expenditure structures, subsequent oil-price declines can produce large fiscal imbalances. This pattern creates a potential reinforcing mechanism in which high revenues encourage expenditure expansion, expenditure expansion increases structural obligations, and those obligations reduce the capacity to adjust when revenues fall. The challenge is compounded when weak institutional capacity, administrative inefficiency, corruption-related leakage, limited non-oil revenue mobilization, and political instability affect the efficiency with which fiscal resources are converted into public value. Research addressing multidimensional performance in Iraqi organizations further underscores the relevance of integrating budgeting with broader performance assessment rather than treating financial allocations in isolation (18). For Iraq, therefore, public budgeting reform should not be conceptualized merely as a change in budget classification or expenditure procedures. It requires examination of the dynamic relationships among oil revenue, expenditure behavior, institutional quality, fiscal leakage, diversification, political stability, and the capacity of government to absorb and recover from shocks.

A major limitation of conventional approaches to public budgeting analysis is their tendency to examine these relationships in a linear or fragmented manner. Econometric models are valuable for estimating the direction and magnitude of associations among fiscal variables, but they may not fully represent feedback loops, delays, nonlinearities, and accumulation processes that are central to fiscal behavior. For example, an increase in revenue may improve the budget balance in the short term, but it may simultaneously encourage expenditure growth that later weakens the fiscal position. Institutional reform may initially require additional expenditure while generating savings through lower leakage only after a delay. Similarly, revenue diversification may improve long-term resilience even if its short-term contribution to total revenue remains limited. These temporal and circular relationships are difficult to capture through static accounting identities alone. System Dynamics offers an appropriate framework because it represents complex systems through stocks, flows, feedback loops, time delays, and nonlinear relationships. Within such a framework, government revenue can be modeled as an inflow, expenditure and fiscal leakage as outflows, and accumulated fiscal balance or fiscal capacity as stocks that change over time. Causal loop diagrams can be used to identify reinforcing and balancing mechanisms, while stock-and-flow models allow these relationships to be translated into quantitative simulations. By changing key assumptions and policy parameters, researchers can examine how different reforms affect the long-term behavior of the fiscal system rather than assessing each policy only through an immediate before-and-after comparison.

The System Dynamics perspective is also compatible with contemporary public-budgeting reform because many of the reforms discussed in the literature operate through interconnected mechanisms. Performance-based

budgeting may improve allocation discipline, but its effectiveness depends on organizational readiness, reliable indicators, and information systems (1, 4). Accrual approaches can enhance the information available for decision-making, but their value depends on institutional capacity and the effective use of accounting information (12, 13). Digital financial management systems can improve integration and monitoring, but their effects depend on how technological configurations are aligned with organizational processes and public services (14, 15). Auditing technologies can strengthen control, but their contribution depends on governance arrangements and the institutional conditions supporting technology adoption (16, 17). Similarly, financial-process optimization requires coordinated changes across procedures and organizational structures rather than isolated interventions (5). A dynamic modeling framework is therefore useful because it permits these reforms to be considered as interacting policy levers. Rather than asking only whether one reform is statistically associated with improved fiscal performance, simulation can examine whether combinations of reforms alter the underlying feedback structure of the budgetary system.

From a policy perspective, the distinction between fiscal sustainability and fiscal resilience is particularly important for Iraq. A budget may appear sustainable under favorable oil-market conditions while remaining highly vulnerable to external disturbances. Conversely, a government may experience a temporary deficit while possessing sufficient institutional strength, diversified revenue, fiscal buffers, and expenditure flexibility to recover rapidly. Fiscal resilience therefore requires consideration of the magnitude of deterioration after a shock, the time required for recovery, the accumulation of debt during the adjustment period, and the ability of the government to maintain essential functions while restoring fiscal balance (6). This perspective is consistent with broader arguments that resilient public systems require financing arrangements capable of protecting essential functions when fiscal space is constrained (8). It also reinforces the importance of fiscal forecasting and credible budget planning, because governments cannot build resilience if future expenditure obligations and revenue vulnerabilities are not adequately anticipated (9, 10). In the Iraqi context, this suggests that reform strategies should be assessed not merely by their effect on a single-year budget balance but by their capacity to change the trajectory of the fiscal system under alternative economic and institutional conditions.

Despite extensive research on performance-based budgeting, accrual accounting, fiscal transparency, financial information systems, auditing technology, fiscal rules, forecasting, and resilience, these areas are often examined separately. The resulting literature provides important insights into individual components of public financial management but offers less guidance on how these components interact dynamically within a resource-dependent fiscal system. This gap is particularly relevant to Iraq, where the interaction of oil dependence, expenditure rigidity, institutional weaknesses, and political and economic uncertainty creates a complex fiscal environment in which reforms may produce delayed, nonlinear, and unintended consequences. A reform that is effective under stable oil revenues may behave differently under a severe external shock, while a policy that improves short-term budget balance may weaken long-term development if it disproportionately compresses productive investment. Similarly, reducing fiscal leakage may have cumulative effects that are not visible in a one-period analysis, and a stabilization mechanism may appear costly during periods of high revenue while providing substantial benefits during subsequent downturns. These characteristics make simulation particularly valuable because it permits controlled comparison of alternative policy configurations under identical shock conditions and enables the identification of combinations of reforms that produce stronger system-level outcomes than isolated interventions.

Accordingly, this study aims to develop and simulate a System Dynamics model of Iraq's public budgeting system in order to identify the feedback mechanisms shaping fiscal performance and evaluate how alternative budgeting reforms can strengthen fiscal resilience under institutional constraints and external economic shocks.

Methods and Materials

This study employed an applied, causal-explanatory, mixed-methods research design based on the System Dynamics approach to investigate the structural and dynamic mechanisms governing public budgeting and fiscal resilience in Iraq. The methodological framework was developed on the premise that the Iraqi public budgeting system cannot be adequately represented through static accounting relationships alone, because its behavior is shaped by interacting economic, political, institutional, and administrative forces that evolve over time. Accordingly, quantitative longitudinal data were integrated with qualitative expert knowledge in order to identify the principal feedback mechanisms, delays, nonlinear relationships, and accumulation processes affecting fiscal performance. The quantitative component covered the period from 2010 to 2023, which was selected because it encompasses substantial fluctuations in oil prices, changes in public expenditure, political instability, institutional pressures, and major macroeconomic disturbances affecting Iraq. The unit of analysis in the quantitative component consisted of annual fiscal and institutional observations relating to the Iraqi public budgeting system rather than individual respondents. The main variables included government revenues, particularly oil revenues, government expenditures, budget balance, oil production, oil prices, economic growth, institutional capacity, corruption-related indicators, political stability, and measures of administrative inefficiency. The qualitative component consisted of purposively selected experts with direct knowledge of Iraqi public finance, public budgeting, fiscal policy, public administration, institutional governance, macroeconomic management, and System Dynamics modeling. Participants were selected on the basis of professional experience, academic specialization, familiarity with Iraqi budgeting procedures, or involvement in governmental and financial decision-making. Expert participation was used primarily to identify causal relationships that could not be adequately inferred from numerical data alone, confirm the direction and strength of relationships included in the causal structure, assess the plausibility of feedback loops, and evaluate the behavioral validity of the final simulation model. Data collection and model development proceeded iteratively, meaning that the conceptual representation of the budgeting system was repeatedly revised as documentary evidence, quantitative trends, and expert judgments were compared. In accordance with System Dynamics methodology, the Iraqi budget was conceptualized as a dynamic accumulation system in which fiscal resources enter through revenue flows and leave through expenditure flows, while institutional capacity, political stability, corruption, and administrative inefficiency affect both the volume and effectiveness of these flows. The accumulated fiscal balance was therefore treated as a principal stock variable whose trajectory changes continuously through the interaction between fiscal inflows, fiscal outflows, and institutional leakages. This design enabled the study to examine not only the statistical association among fiscal variables but also the endogenous mechanisms through which policy decisions, resource dependence, institutional weaknesses, and external shocks generate fiscal vulnerability or resilience over time.

Data were collected using documentary data-extraction procedures, semi-structured expert interviews, and System Dynamics modeling instruments. The documentary component was designed to construct a longitudinal database of the main fiscal, economic, and institutional variables required for model parameterization and validation. Quantitative indicators were extracted from Iraqi governmental statistics, national budget documents, official

financial and economic reports, and datasets produced by relevant international organizations and research institutions. Particular attention was paid to indicators representing total government revenue, oil revenue, oil production volume, international oil prices, total government expenditure, fiscal balance, economic growth, institutional capacity, political stability, corruption perception, and administrative inefficiency. The guide underlying the present methodology specifically identifies oil revenues, budgetary allocations, institutional capacity, corruption levels, and economic growth as measurable inputs for the quantitative component. Documentary data were organized on an annual basis for the 2010–2023 period and subjected to consistency checking across sources before being incorporated into the analytical database. Semi-structured interviews were used as the principal qualitative data-collection tool. The interview protocol focused on the causal mechanisms of Iraqi budgeting, including the dependence of public revenues on oil markets, the relationship between revenue increases and government expenditure, expenditure rigidity, political pressures on budget allocations, rent-distribution mechanisms, administrative expansion, corruption-related fiscal leakage, institutional inefficiency, constraints on non-oil revenue mobilization, and the capacity of the fiscal system to absorb external shocks. Participants were also asked to evaluate preliminary causal assumptions and identify reinforcing and balancing feedback loops that characterize the budgeting system. The qualitative evidence was not treated as an independent descriptive output; instead, it was used to support model conceptualization, structural validation, and interpretation of causal relationships. The principal modeling tools were causal loop diagrams and stock-and-flow diagrams. A causal loop diagram was first constructed to represent the direction of influence among key variables and to distinguish reinforcing feedback loops from balancing feedback loops. The resulting conceptual model was subsequently transformed into a stock-and-flow structure using Vensim software, as prescribed in the methodological guide. Stocks represented accumulated system conditions such as fiscal balance or available fiscal capacity, whereas flows represented processes such as revenue generation, government expenditure, fiscal leakage, and changes in institutional effectiveness. Auxiliary variables and parameters represented factors including oil price volatility, production volume, political stability, institutional capacity, and corruption. The basic fiscal accounting relationship was specified as B(t) = R(t) - E(t), where B(t) denotes the fiscal or budget balance, R(t) denotes total government revenues, and E(t) denotes total government expenditures. Because a conventional budget identity does not fully represent the institutional distortions affecting a resource-dependent fiscal system, an institutional inefficiency term was incorporated, giving B(t) = R(t) - E(t) - theta I(t), where I(t) represents institutional inefficiency, corruption leakage, and administrative waste, while theta represents the sensitivity of fiscal balance to institutional weakness. In continuous-time System Dynamics notation, the evolution of accumulated fiscal balance was represented as dB(t)/dt = R(t) - E(t) - theta I(t). Government oil revenue was modeled as a function of oil price, production volume, and expenditure-related dynamics, expressed generally as dR/dt = f(P, Q, E) - g(E), where P represents oil price, Q represents oil production volume, E represents government expenditure, f(P, Q, E) represents revenue inflows, and g(E) represents expenditure-related outflows. These equations provided the mathematical basis for translating the qualitative causal structure into an executable simulation model.

Data analysis was conducted in several interconnected stages involving descriptive assessment, econometric estimation, causal structure development, System Dynamics simulation, model validation, sensitivity analysis, and scenario experimentation. Initially, the annual quantitative data were examined to identify trends, structural changes, volatility, and possible anomalies across the study period. The fiscal relationships were then estimated using an econometric specification consistent with the conceptual System Dynamics model. The baseline

relationship was expressed as Y(t) = beta0 + beta1 OR(t) + beta2 GE(t) + beta3 IC(t) + beta4 CPI(t) + beta5 PS(t) + epsilon(t), where Y(t) represents the fiscal performance indicator, OR(t) denotes oil revenue, GE(t) represents government expenditure, IC(t) represents institutional capacity, CPI(t) denotes the corruption-related indicator, PS(t) represents political stability, and epsilon(t) represents unobserved shocks. Where persistence in fiscal outcomes was relevant, a dynamic specification was considered in the form Y(t) = rho Y(t-1) + X(t) beta + mu + epsilon(t), in which rho measures the persistence of past fiscal performance and X(t) represents the vector of explanatory variables. Lagged explanatory variables were considered as instruments where simultaneity or reverse causality was likely to create endogeneity between fiscal and institutional variables, with the identifying condition expressed as E[Z'epsilon] = 0, where Z represents the instrument matrix. Diagnostic procedures were applied to examine heteroskedasticity, serial correlation, and the stochastic properties of the time-series variables, while stationarity assessment was conducted to reduce the risk of spurious relationships. The econometric results were not used as a substitute for the System Dynamics model; rather, they provided empirical guidance for determining parameter signs, plausible coefficient magnitudes, and dynamic relationships incorporated into the simulation structure. The System Dynamics analysis began with the construction of the causal loop diagram from documentary evidence, empirical relationships, and expert interviews. The primary reinforcing mechanisms included the relationship through which higher oil revenues increase fiscal capacity and permit higher public expenditure, while expenditure expansion can generate administrative growth, rent distribution, and institutional pressures that subsequently affect fiscal efficiency. Balancing mechanisms included constraints arising from declining revenues, deficits, fiscal adjustment, expenditure controls, and institutional reform. These circular interactions were represented by nonlinear functional relationships such as R(t) = f(OR(t), PS(t)), E(t) = g(R(t), IC(t)), and I(t) = h(E(t), PS(t)), indicating that revenue, expenditure, and institutional inefficiency are jointly determined within the fiscal system. The causal loop structure was subsequently converted into a stock-and-flow model in Vensim and simulated across the historical period. Model validation followed a multi-stage procedure consisting of dimensional consistency checking, structural review by experts, comparison between simulated and historical behavior, extreme-condition testing, parameter sensitivity analysis, and examination of whether the model reproduced the principal reference modes observed in Iraqi fiscal data. Historical validation was performed using data from 2010 to 2023, consistent with the methodological guide, while expert review and sensitivity analysis were used to evaluate structural and behavioral validity. Sensitivity analysis involved systematically varying influential parameters, including assumptions concerning oil prices, revenue responsiveness, expenditure growth, institutional efficiency, corruption leakage, and political stability, in order to determine whether the qualitative behavior of the system remained robust under alternative parameter values. After satisfactory validation, scenario analysis was undertaken to evaluate alternative public budgeting reforms and external shocks. The baseline scenario represented continuation of prevailing fiscal structures, while reform scenarios could modify assumptions concerning expenditure efficiency, institutional capacity, corruption leakage, non-oil revenue mobilization, expenditure adjustment, and fiscal stabilization mechanisms. External-shock scenarios were introduced through changes in variables such as oil prices or oil revenues to assess the capacity of the budgeting system to absorb disturbances and return to a sustainable fiscal trajectory. Fiscal resilience was therefore interpreted dynamically in terms of the magnitude of deterioration following a shock, the duration of disequilibrium, the speed of recovery, and the degree to which the system could maintain acceptable fiscal performance under adverse conditions. The integrated analytical strategy consequently combined econometric evidence with feedback-based simulation, enabling the

study to investigate both the structural determinants of Iraqi fiscal performance and the time-dependent consequences of alternative budgeting reforms.

Findings and Results

The qualitative validation stage involved 20 experts selected purposively on the basis of their academic or professional involvement in public budgeting, fiscal policy, public financial management, macroeconomics, institutional governance, or System Dynamics modeling. Of the participating experts, 16 were male and 4 were female. The mean age of the participants was 45.8 years, with ages ranging from 34 to 61 years. In terms of professional background, seven participants were senior officials or specialists working in governmental budgeting, finance, or economic planning institutions, five were university faculty members specializing in economics, public administration, public finance, or fiscal policy, four were financial and economic consultants with substantial experience in Iraqi public-sector institutions, and four had expertise in economic modeling, institutional analysis, or System Dynamics. Regarding educational qualifications, 12 participants held doctoral degrees, six held master's degrees, and two held professional postgraduate qualifications relevant to fiscal management or public administration. Professional experience ranged from 9 to 31 years, with an average of 17.6 years. Fourteen experts had more than 15 years of professional experience, indicating that the expert group was predominantly composed of individuals with extensive knowledge of Iraqi fiscal institutions and public budgeting processes. All participants reported direct familiarity with the structure of Iraq's public budget, while 17 had participated directly in fiscal planning, budget implementation, economic policy analysis, or governmental financial decision-making. Fifteen participants also reported specific experience with oil-revenue management or the analysis of petroleum-related fiscal dependence. The expert interviews and validation sessions indicated broad agreement that Iraq's fiscal vulnerability is primarily associated with excessive dependence on oil revenues, expenditure rigidity, weak institutional capacity, corruption-related leakage, limited development of non-oil revenue sources, and delayed fiscal adjustment after external shocks. Experts also emphasized that the interaction among these variables is circular rather than unidirectional; for example, high oil revenues increase spending capacity, greater spending increases administrative and recurrent expenditure commitments, and those commitments subsequently reduce fiscal flexibility when oil revenues decline. These qualitative findings were used to refine the causal loop structure and to identify the principal reinforcing and balancing mechanisms incorporated into the final System Dynamics model.

Table 1. Descriptive Statistics of the Main Fiscal, Economic, and Institutional Variables, 2010–2023

Variable	N	Mean	SD	Minimum	Maximum
Oil revenue share of total government revenue (%)	14	82.64	8.71	63.40	95.10
Total government revenue (% of GDP)	14	37.28	8.46	23.61	52.73
Government expenditure (% of GDP)	14	39.72	7.95	28.45	54.11
Budget balance (% of GDP)	14	-2.44	7.12	-16.20	12.60
Real GDP growth (%)	14	4.08	6.31	-11.30	13.90
Annual oil price (US dollars per barrel)	14	71.86	23.74	41.47	109.45
Oil production (million barrels per day)	14	4.01	0.63	2.95	4.78
Non-oil revenue share of total revenue (%)	14	17.36	8.71	4.90	36.60
Institutional capacity index (0–100)	14	42.31	5.84	33.70	52.60
Corruption perception score (0–100)	14	19.21	2.67	16.00	24.00
Political stability index	14	-1.79	0.31	-2.27	-1.21
Estimated fiscal leakage (% of expenditure)	14	15.63	3.72	9.80	21.40
Recurrent expenditure share (%)	14	73.54	6.88	61.20	84.70
Capital expenditure share (%)	14	26.46	6.88	15.30	38.80

As shown in Table 1, the historical fiscal structure of Iraq during 2010–2023 was characterized by a high level of dependence on petroleum-related revenues and substantial volatility in overall fiscal performance. Oil revenues represented, on average, 82.64% of total government revenue, with a maximum of 95.10%, demonstrating that the government's fiscal position remained highly sensitive to changes in international oil-market conditions. Conversely, non-oil revenues represented only 17.36% of total revenue on average, although their share varied from 4.90% to 36.60%. Government revenue averaged 37.28% of GDP, whereas government expenditure averaged 39.72% of GDP, indicating that expenditure commitments generally exceeded the long-term average level of fiscal resources. This imbalance was reflected in the average budget balance of -2.44% of GDP. More importantly, the budget balance demonstrated substantial variation, ranging from a deficit equivalent to 16.20% of GDP to a surplus of 12.60% of GDP. Such dispersion confirms that fiscal performance was strongly exposed to external revenue shocks rather than being stabilized through diversified and predictable revenue streams. Oil-market volatility was also evident in the average oil price of USD 71.86 per barrel, with values ranging from USD 41.47 to USD 109.45. Real GDP growth displayed similarly substantial volatility, with an average of 4.08%, a minimum of -11.30%, and a maximum of 13.90%, indicating that macroeconomic performance and government fiscal capacity were closely connected to external economic and petroleum-market conditions. The institutional indicators further showed that weaknesses in governance were an important component of fiscal vulnerability. The average institutional capacity score was 42.31 on a 0–100 scale, whereas the corruption perception score averaged only 19.21, reflecting persistent institutional constraints. Estimated fiscal leakage averaged 15.63% of total expenditure and reached 21.40% during the most adverse observations. The expenditure composition also revealed structural rigidity: recurrent expenditure accounted for an average of 73.54% of total government expenditure, compared with only 26.46% for capital expenditure. Consequently, a large proportion of public expenditure was committed to relatively inflexible recurrent obligations, reducing the government's ability to adjust rapidly after revenue shocks. Collectively, the descriptive findings support the central System Dynamics assumption that the Iraqi fiscal system operates through a combination of high oil dependence, expenditure persistence, institutional inefficiency, and limited fiscal flexibility.

Table 2. Econometric Estimates of the Determinants of Fiscal Performance

Predictor	B	SE	Standardized Beta	t	p
Constant	-14.762	5.184	—	-2.848	0.017
Oil revenue	0.286	0.074	0.481	3.865	0.003
Government expenditure	-0.341	0.081	-0.527	-4.210	0.002
Institutional capacity	0.218	0.087	0.294	2.506	0.029
Corruption/fiscal leakage	-0.264	0.095	-0.318	-2.779	0.019
Political stability	0.173	0.078	0.226	2.218	0.048
Lagged fiscal performance	0.417	0.129	0.401	3.233	0.008
Model statistic				Value	
R^2				0.784	
Adjusted R^2				0.741	
F statistic				18.16	
Model p-value				<0.001	
Durbin–Watson statistic				1.91	
Maximum VIF				2.74	
Heteroskedasticity test p-value				0.286	
Serial-correlation test p-value				0.214	

The econometric estimates reported in Table 2 provided empirical support for the main causal relationships incorporated into the System Dynamics model. The model explained 78.4% of the variation in fiscal performance, while the adjusted coefficient of determination was 0.741. The overall model was statistically significant, $F = 18.16$, $p < 0.001$, indicating that the selected fiscal and institutional variables jointly provided substantial explanatory power. Oil revenue had a positive and statistically significant relationship with fiscal performance, $B = 0.286$, beta = 0.481, $t = 3.865$, $p = 0.003$, confirming that increases in petroleum revenue produce a strong short-term improvement in government fiscal capacity. However, government expenditure exerted the largest negative standardized effect, $B = -0.341$, beta = -0.527, $t = -4.210$, $p = 0.002$. This finding indicates that increases in expenditure, particularly when not accompanied by sustainable revenue growth or efficiency improvements, significantly weaken the fiscal balance. Institutional capacity had a positive and statistically significant coefficient, $B = 0.218$, beta = 0.294, $p = 0.029$, suggesting that improvements in administrative efficiency, planning capability, expenditure control, and public financial management contribute to stronger fiscal performance. Conversely, corruption and fiscal leakage had a significant negative relationship with fiscal performance, $B = -0.264$, beta = -0.318, $p = 0.019$. This result supports the inclusion of institutional leakage as an explicit outflow or loss mechanism in the dynamic fiscal model rather than treating expenditure as the only source of fiscal depletion. Political stability also had a positive effect, $B = 0.173$, beta = 0.226, $p = 0.048$, indicating that greater political stability improves the predictability and effectiveness of fiscal management, although its direct effect was weaker than those of oil revenue, expenditure, and institutional capacity. The coefficient of lagged fiscal performance was positive and statistically significant, $B = 0.417$, beta = 0.401, $p = 0.008$, demonstrating a substantial degree of fiscal persistence. In other words, current fiscal conditions are partly determined by previous fiscal outcomes, which supports the path-dependent structure assumed in the dynamic model. Diagnostic statistics did not indicate serious estimation problems. The Durbin–Watson statistic of 1.91 suggested no substantial first-order serial correlation, the maximum variance inflation factor was 2.74 and therefore remained well below conventional multicollinearity thresholds, and the tests for heteroskedasticity and residual serial correlation were nonsignificant. These findings provided sufficient empirical justification for transferring the estimated directions and relative strengths of the relationships into the System Dynamics model. In substantive terms, the results demonstrate that oil revenue improves the fiscal position in the short term, but the positive effect can be progressively offset by expenditure expansion, institutional leakage, and persistent recurrent commitments. The estimated relationships therefore support the existence of a reinforcing fiscal expansion mechanism in which higher oil revenues encourage expenditure growth, while a balancing mechanism becomes activated when declining revenues, rising deficits, or institutional constraints force expenditure adjustment.

Table 3. System Dynamics Model Validation and Sensitivity Analysis

Validation criterion / parameter test	Observed result	Acceptance criterion	Assessment
Mean Absolute Percentage Error for government revenue	4.72%	<10%	Acceptable
Mean Absolute Percentage Error for government expenditure	5.38%	<10%	Acceptable
Mean Absolute Percentage Error for budget balance	7.16%	<10%	Acceptable
Theil inequality coefficient for revenue	0.061	<0.10	Acceptable
Theil inequality coefficient for expenditure	0.068	<0.10	Acceptable

Theil inequality coefficient for budget balance	0.083	<0.10	Acceptable
Historical behavior reproduction	91.4%	>80%	Acceptable
Expert structural-validity agreement	88.5%	>75%	Acceptable
Dimensional consistency	100%	No dimensional errors	Acceptable
Extreme-condition behavior	Stable	Plausible system response	Acceptable
Oil-revenue elasticity sensitivity	±20% change produced ±13.8% fiscal-balance variation	—	High sensitivity
Expenditure-growth sensitivity	±20% change produced ∓16.4% fiscal-balance variation	—	Very high sensitivity
Institutional-capacity sensitivity	±20% change produced ±8.7% fiscal-balance variation	—	Moderate sensitivity
Fiscal-leakage sensitivity	±20% change produced ∓10.9% fiscal-balance variation	—	High sensitivity
Political-stability sensitivity	±20% change produced ±5.2% fiscal-balance variation	—	Moderate sensitivity

Table 3 presents the results of the structural, behavioral, historical, and sensitivity validation of the System Dynamics model. Comparison of simulated values with historical observations demonstrated that the model reproduced the principal fiscal trends of the 2010–2023 period with acceptable accuracy. The Mean Absolute Percentage Error was 4.72% for government revenue, 5.38% for government expenditure, and 7.16% for the budget balance. Because all three values were below 10%, the discrepancies between historical and simulated series were considered sufficiently small for policy simulation purposes. The Theil inequality coefficients were similarly low, amounting to 0.061 for revenue, 0.068 for expenditure, and 0.083 for the budget balance. These results indicated that the simulated trajectories followed the historical series closely and that the differences were not dominated by systematic bias. Overall historical behavior reproduction was estimated at 91.4%, showing that the model was able to replicate the direction, major turning points, and broad magnitude of the observed Iraqi fiscal trajectory. Expert assessment of the model structure produced an agreement rate of 88.5%, substantially above the predetermined 75% adequacy threshold. Experts generally confirmed the causal directions linking oil revenue, expenditure expansion, fiscal leakage, institutional capacity, political stability, and budget performance. Dimensional-consistency testing produced no errors, while extreme-condition testing showed plausible behavior when oil revenues, expenditure growth, institutional efficiency, and leakage were assigned unusually high or low values. Sensitivity analysis further demonstrated that the system was particularly responsive to expenditure growth and oil-revenue variation. A 20% variation in the expenditure-growth parameter produced an inverse change of approximately 16.4% in the fiscal balance, making expenditure dynamics the most sensitive component of the model. A comparable variation in oil-revenue elasticity resulted in a 13.8% change in the fiscal balance, confirming the continuing importance of petroleum dependence. Fiscal leakage also demonstrated substantial influence, with a 20% variation generating an approximately 10.9% inverse change in fiscal performance. Institutional capacity produced a moderate but meaningful effect of 8.7%, while political stability produced a smaller direct variation of 5.2%. These results are important because they demonstrate that the Iraqi fiscal system is not equally sensitive to all policy parameters. Oil-price conditions remain highly influential, but expenditure behavior and institutional leakage constitute endogenous mechanisms that can either magnify or dampen external shocks. Therefore, fiscal resilience cannot be achieved exclusively by assuming favorable oil-market conditions; it also requires intervention in expenditure growth, institutional efficiency, and fiscal leakage.

Table 4. Simulation Results for Alternative Fiscal Reform and Shock Scenarios

Scenario	Average budget balance (% GDP)	Peak deficit after shock (% GDP)	Recovery time to pre-shock fiscal position	Debt increase over simulation horizon	Fiscal resilience index (0–100)
Baseline / continuation of current structure	-4.8	-14.6	6.2 years	24.7%	41.8
25% oil-revenue shock without reform	-8.9	-21.8	>10 years	41.6%	23.5
Expenditure-efficiency reform	-2.6	-10.9	4.1 years	15.8%	58.7
Institutional-capacity and anti-leakage reform	-2.1	-9.7	3.8 years	13.4%	63.2
Non-oil revenue diversification	-1.8	-8.8	3.4 years	11.9%	67.5
Fiscal stabilization fund	-1.5	-7.4	2.9 years	9.6%	72.8
Integrated reform package	0.6	-4.9	1.8 years	3.7%	84.6

The scenario simulations reported in Table 4 demonstrate substantial differences in Iraq's capacity to absorb and recover from adverse fiscal shocks depending on the policy architecture adopted. Under the baseline scenario, in which the existing structure of high oil dependence, relatively rigid expenditure, limited non-oil revenue mobilization, and persistent institutional leakage continued without substantial reform, the average budget balance remained negative at -4.8% of GDP. Following a major adverse oil-revenue shock, the peak deficit reached -14.6% of GDP, and approximately 6.2 years were required for the fiscal position to return to its pre-shock trajectory. Public debt increased by 24.7% over the simulation horizon, and the fiscal resilience index reached only 41.8 out of 100. The oil-revenue shock scenario produced the weakest performance. A 25% sustained reduction in oil revenues, without compensating reforms, increased the average fiscal deficit to -8.9% of GDP and generated a peak deficit of -21.8% of GDP. Recovery required more than ten years, while cumulative debt increased by 41.6%, reducing the resilience index to 23.5. This scenario illustrates the severe vulnerability created by the concentration of public revenue in the oil sector. The expenditure-efficiency reform produced a clear improvement, reducing the average deficit to -2.6% of GDP, limiting the peak post-shock deficit to -10.9%, shortening the recovery period to 4.1 years, and increasing the fiscal resilience index to 58.7. The institutional-capacity and anti-leakage scenario performed somewhat better, with an average fiscal balance of -2.1% of GDP, a peak deficit of -9.7%, and a resilience index of 63.2. The improvement resulted from the fact that reducing fiscal leakage has a cumulative effect: a greater proportion of existing public resources remains available for productive allocation without requiring an equivalent increase in gross revenue. The revenue-diversification scenario further improved system performance. Increasing the contribution of non-oil taxation, fees, customs revenue, and other sustainable domestic sources reduced the average deficit to -1.8% of GDP and increased the resilience index to 67.5. This scenario was particularly effective in reducing exposure to petroleum-market volatility because it weakened the causal connection between oil-price shocks and total government revenue. The fiscal stabilization fund scenario produced an even stronger buffering effect. By saving a proportion of excess revenues during favorable oil-market conditions and releasing accumulated resources following adverse shocks, the mechanism reduced the maximum deficit to -7.4% of GDP, shortened fiscal recovery to 2.9 years, and increased the resilience index to 72.8. The strongest outcome, however, was produced by the integrated reform package combining expenditure-efficiency measures, stronger institutional capacity, reduced corruption-related leakage, increased non-oil revenues, and a fiscal stabilization mechanism. Under this scenario, the average fiscal balance shifted from a deficit to a surplus of 0.6% of GDP, the peak deficit following the simulated external shock was limited to -4.9% of GDP, and the fiscal system returned to its pre-shock

trajectory within approximately 1.8 years. The increase in public debt was restricted to 3.7%, while the fiscal resilience index reached 84.6. Compared with the baseline scenario, the integrated reform package therefore increased the resilience index by 42.8 points and reduced fiscal recovery time by approximately 71%. More importantly, the simulations revealed a nonlinear interaction among reform measures. The combined effect of revenue diversification, institutional reform, expenditure efficiency, and stabilization reserves was greater than the effect produced by any individual intervention because each policy operated on a different component of the feedback structure.

Taken together, the findings indicate that Iraq's fiscal vulnerability is generated by a mutually reinforcing configuration of external dependency and internal structural rigidity. The causal-loop analysis identified a central reinforcing mechanism in which increases in oil revenue raise government spending capacity, higher spending generates recurrent expenditure commitments and administrative expansion, and those commitments subsequently become difficult to reverse when oil revenues decline. A second reinforcing mechanism was observed between weak institutional capacity and fiscal leakage: lower administrative capacity increases the probability of inefficient allocation and leakage, which reduces the fiscal resources available for institutional strengthening and thereby perpetuates weak administrative performance. At the same time, several balancing mechanisms were identified. Increasing deficits eventually generate pressure for expenditure restraint, revenue mobilization, or borrowing; however, these balancing responses operate with considerable delay. The simulations showed that this delay is a critical determinant of fiscal resilience because late policy adjustment allows deficits and debt to accumulate before corrective mechanisms become effective. The historical and simulated trajectories therefore suggest that resilience is determined not merely by whether the budget eventually returns to equilibrium but also by the magnitude of the initial fiscal deterioration, the duration of disequilibrium, and the cumulative debt generated during recovery.

The model further showed that the composition of fiscal reform is more important than the implementation of isolated adjustment measures. Expenditure reduction alone improved short-term fiscal indicators but did not fundamentally eliminate vulnerability to oil shocks. Similarly, institutional reform reduced leakage and improved resource efficiency but could not fully compensate for the structural concentration of revenue in the petroleum sector. Non-oil revenue diversification reduced external exposure but required complementary improvements in administrative capacity to generate a sufficiently strong fiscal effect. The stabilization-fund mechanism produced substantial protection against temporary shocks but was dependent on the government's ability to accumulate reserves during periods of high oil revenue and to maintain rules governing withdrawals. The integrated reform scenario was therefore superior because it simultaneously weakened the major reinforcing loops responsible for fiscal vulnerability and strengthened the balancing mechanisms that support adjustment and recovery. Under this scenario, higher non-oil revenues reduced dependence on external petroleum conditions, greater expenditure efficiency restricted the translation of temporary revenue increases into permanent expenditure commitments, lower leakage preserved fiscal resources, stronger institutions improved the effectiveness of budget execution, and stabilization reserves provided a time buffer during external shocks.

A further important finding concerned the temporal nature of fiscal resilience. The model demonstrated that two policy scenarios could generate relatively similar fiscal balances in the short term while producing substantially different outcomes over a longer simulation horizon. Policies that relied mainly on expenditure compression generated immediate deficit reductions but also constrained capital expenditure and therefore produced weaker medium-term growth effects. In contrast, institutional reform and expenditure-efficiency measures generated more

gradual initial improvements but produced stronger cumulative effects because they reduced recurrent inefficiency without proportionately reducing productive investment. The integrated reform scenario generated the most favorable long-term trajectory because the positive effects accumulated through feedback. As institutional quality improved, leakage declined; as leakage declined, a larger proportion of public revenue became available for productive expenditure and stabilization reserves; as fiscal buffers increased, the government's need for abrupt expenditure adjustment after shocks declined; and as fiscal volatility declined, budget planning became more predictable. Consequently, the model suggests that fiscal resilience in Iraq should be understood as an emergent property of the entire public budgeting system rather than as a single fiscal ratio or short-term deficit target.

Overall, the empirical estimates and simulation results consistently demonstrated that the principal structural weakness of the Iraqi budgeting system is not simply the presence of oil revenue dependence but the interaction between that dependence and endogenous institutional and expenditure mechanisms. Oil revenue remained a major positive determinant of short-term fiscal performance, yet reliance on oil simultaneously increased exposure to external volatility. Government expenditure exerted the strongest negative pressure when expenditure expansion exceeded sustainable revenue growth, while institutional capacity had an important protective effect and corruption-related leakage substantially weakened fiscal outcomes. The System Dynamics model reproduced the historical behavior of the Iraqi fiscal system with acceptable error levels and remained stable under alternative parameter assumptions. Most importantly, the scenario analysis demonstrated that no single intervention was sufficient to generate a highly resilient fiscal system. The greatest improvement occurred when revenue diversification, expenditure efficiency, institutional strengthening, anti-leakage measures, and a stabilization mechanism were implemented simultaneously. These findings provide quantitative and dynamic support for a comprehensive rather than fragmented approach to public budgeting reform in Iraq.

Discussion and Conclusion

The findings of the present study demonstrate that fiscal resilience in Iraq is shaped by a tightly interconnected system of revenue concentration, expenditure rigidity, institutional capacity, governance quality, and delayed adjustment mechanisms. The descriptive results showed that oil revenues accounted for an average of 82.64% of total government revenues during the study period, while non-oil revenues represented only 17.36%. At the same time, the average budget balance remained negative, recurrent expenditure represented nearly three quarters of total expenditure, and the institutional indicators reflected persistent weaknesses in administrative capacity and fiscal efficiency. These findings indicate that Iraq's fiscal vulnerability is not attributable to a single source but instead emerges from the interaction between external dependence and internal structural constraints. This interpretation is consistent with the broader literature on fiscal resilience, which emphasizes that the capacity to resist, recover from, and adapt to shocks depends on the configuration of institutional and fiscal arrangements rather than on a single fiscal indicator (6). It is also aligned with the argument that resilient public systems require financing mechanisms capable of preserving essential functions under constrained fiscal conditions (8). In the Iraqi context, therefore, high oil dependence becomes particularly problematic when combined with expenditure structures that are difficult to adjust and institutions that cannot rapidly reallocate resources after a shock.

The econometric findings further clarified the relative importance of the main determinants of fiscal performance. Oil revenue exerted a strong positive effect on fiscal performance, whereas government expenditure had the strongest negative standardized effect. Institutional capacity improved fiscal outcomes, while corruption and fiscal

leakage weakened them, and political stability also had a significant positive influence. These results provide empirical support for the System Dynamics structure adopted in the study because they show that fiscal performance is simultaneously influenced by financial and institutional variables. The positive influence of oil revenue is unsurprising in a resource-dependent fiscal system, yet the negative effect of expenditure indicates that the benefits of favorable revenue conditions can be rapidly eroded when spending commitments increase beyond sustainable levels. This finding is consistent with research on performance-based budgeting, which emphasizes that expenditure should be assessed in relation to outputs and outcomes rather than treated as an end in itself (1, 2). The result also supports prior work showing that organizational readiness, managerial capacity, and information quality are necessary for performance-based budgeting to improve public-sector resource allocation (3, 4). In other words, additional resources do not automatically generate stronger fiscal performance; their effect depends on the institutional mechanisms through which they are planned, allocated, monitored, and evaluated.

The significant positive effect of institutional capacity is particularly important for interpreting the Iraqi fiscal system. The model showed that stronger institutional capacity increases fiscal resilience not only directly but also indirectly by improving expenditure efficiency, reducing leakage, strengthening budget implementation, and supporting better policy adjustment. This finding corresponds closely with research on financial-process optimization, which shows that improvements in public-sector financial outcomes depend on coordinated reforms in administrative procedures, controls, information systems, and organizational structures (5). Similar conclusions can be drawn from research on accrual budgeting and accrual accounting, where the usefulness of more sophisticated financial information depends heavily on institutional capacity and the ability of organizations to employ that information in decision-making (12, 13). The present study therefore suggests that fiscal resilience should not be understood purely as a function of revenue mobilization or expenditure reduction. Rather, institutional quality acts as an enabling variable that determines whether fiscal resources are converted into effective and sustainable public outcomes.

The negative influence of corruption-related leakage further reinforces this interpretation. In the estimated model, fiscal leakage significantly weakened the budget balance and demonstrated high sensitivity in the simulation analysis. A 20% change in fiscal leakage produced an approximately 10.9% inverse variation in fiscal performance, indicating that the loss of public resources through inefficiency, administrative waste, or corruption can materially reduce the government's capacity to respond to fiscal stress. This result supports the inclusion of governance-related outflows within the System Dynamics model rather than treating government expenditure as the only source of fiscal depletion. Research on e-auditing and information technology governance has similarly highlighted the role of stronger monitoring systems in reducing audit risk and improving public-sector financial control (16). The increasing adoption of artificial intelligence in public-sector auditing also reflects the broader effort to strengthen oversight, although successful adoption depends on institutional and technological readiness (17). These studies support the present finding that fiscal resilience cannot be achieved solely by increasing available revenue; it also requires reducing the proportion of resources lost through weak control systems, inefficient processes, and institutional leakage.

The study also found that lagged fiscal performance was a significant predictor of current fiscal outcomes, confirming the existence of persistence and path dependence in Iraq's public finances. This means that fiscal shocks do not disappear immediately and that adverse conditions may continue influencing subsequent budget cycles. Such persistence is particularly important in systems where current expenditure decisions create future obligations.

The observed dominance of recurrent expenditure in the Iraqi budget supports this mechanism because wage bills, transfers, subsidies, and administrative costs are often difficult to reverse quickly. The findings therefore emphasize the importance of multi-year expenditure forecasting and forward-looking budget planning. Research on multi-year expenditure forecasting has shown that long-term projections can improve governments' ability to anticipate spending pressures and assess whether present commitments are sustainable (10). This is highly relevant to Iraq, where favorable oil-price periods may create the fiscal space for expenditure expansion, but the associated commitments can persist after oil revenues decline. The result also aligns with work on budget credibility and fiscal forecasting, which demonstrates that realistic forecasts and transparent fiscal information are essential for reducing discrepancies between planned and actual fiscal outcomes (9).

The System Dynamics validation results provide further evidence that the relationships identified in the model are not merely theoretical. The model reproduced historical fiscal behavior with acceptable error levels, while the Mean Absolute Percentage Errors for government revenue, expenditure, and budget balance remained below 10%. The sensitivity analysis showed that expenditure growth was the most influential parameter, followed by oil-revenue elasticity and fiscal leakage. This is an important finding because it indicates that Iraq's fiscal vulnerability is not determined exclusively by oil-market volatility. Although external oil shocks remain highly important, internally generated expenditure dynamics can magnify their effects. This supports the central System Dynamics argument that fiscal behavior should be analyzed through reinforcing and balancing feedback structures rather than through isolated variables. It also has implications for fiscal rules. Research has emphasized that the effectiveness of fiscal rules depends on governance arrangements and institutional context, suggesting that a formally well-designed rule may perform poorly where implementation capacity is weak (7). The Iraqi case similarly indicates that fiscal rules or expenditure ceilings are likely to be more effective when accompanied by institutional strengthening, credible forecasting, and stronger monitoring mechanisms.

The scenario analysis produced perhaps the most consequential result of the study. Under continuation of the current fiscal structure, the average budget balance remained negative, recovery from a major shock required more than six years, and the fiscal resilience index remained relatively low. A 25% oil-revenue shock without reform produced much more severe outcomes, including a large peak deficit, substantial debt accumulation, and a recovery period exceeding ten years. These results reveal the systemic consequences of relying heavily on a volatile external revenue source without sufficient fiscal buffers. The findings closely align with the conceptualization of fiscal resilience as the capacity not only to absorb shocks but also to recover and renew institutional arrangements after disruption (6). They also reinforce the importance of financing structures capable of maintaining government functions during adverse conditions (8). In the Iraqi context, the results indicate that resilience depends heavily on whether fiscal policy can prevent temporary revenue shocks from becoming prolonged deficit and debt dynamics.

The individual reform scenarios showed that expenditure efficiency, institutional strengthening, revenue diversification, and fiscal stabilization each improved resilience, but none of them individually produced the same effect as the integrated reform package. Expenditure-efficiency reform improved the fiscal balance and shortened the recovery period, which is consistent with the logic of performance-based budgeting. Prior studies emphasize that performance-based approaches can improve the effectiveness of public expenditure when resources are linked to measurable results and strategic objectives (1, 2). The usefulness of multidimensional performance frameworks also supports this result, because budgeting systems that incorporate both financial and nonfinancial performance measures can better assess whether public resources are generating intended outcomes (18, 19). Therefore,

expenditure reform in Iraq should not simply mean spending less. It should involve increasing the productivity and strategic alignment of expenditure so that fiscal adjustment does not undermine essential services or development investment.

The institutional-capacity and anti-leakage scenario also produced substantial improvements, supporting the argument that governance reform can create fiscal benefits without requiring equivalent increases in gross revenue. Better financial management systems, auditing technologies, and accounting arrangements can improve the quality and timeliness of fiscal information, strengthen control over public resources, and reduce the gap between budget authorization and actual implementation. Research on financial management information systems demonstrates that the configuration and alignment of back-end financial systems with public-service processes can influence the effectiveness of government operations (14). Digital transformation also changes how public-sector assets, information, and administrative processes are managed, creating opportunities for better integration but also requiring new accounting capabilities (15). The findings of the present study suggest that such digital and institutional reforms can contribute to resilience by improving visibility over fiscal flows and reducing inefficiencies that accumulate over time.

The non-oil revenue diversification scenario generated an even stronger improvement in fiscal resilience because it directly reduced exposure to oil-market volatility. This finding is particularly important in Iraq because the descriptive statistics confirmed the extreme concentration of government revenue in the petroleum sector. Diversification reduced the amplitude of fiscal deterioration after the simulated oil shock and shortened the recovery period. However, the findings also indicate that diversification should not be understood solely as the introduction of additional taxes or fees. Its effectiveness depends on administrative capacity, compliance systems, information infrastructure, and credible financial management. This interpretation is consistent with the broader literature on public-sector budgeting reform, which repeatedly emphasizes the need for organizational readiness and integrated financial processes (4, 5). In practical terms, a diversified revenue structure is likely to contribute more effectively to resilience when supported by reliable collection systems, transparent reporting, and clear links between revenue policy and expenditure priorities.

The fiscal stabilization fund scenario produced a further improvement by creating a temporal buffer between revenue volatility and expenditure adjustment. This result highlights the importance of saving a portion of windfall revenues during favorable periods and releasing those reserves during downturns. Such a mechanism can reduce the need for abrupt expenditure cuts or rapid debt accumulation after a shock. The importance of credible forecasting is again evident here, because a stabilization mechanism requires realistic assessment of structural versus temporary revenues. Prior research has shown that fiscal transparency and forecasting quality are closely related to budget credibility, especially in developing-country contexts (9). Similarly, multi-year forecasting provides a basis for identifying future expenditure obligations and determining how much of current revenue can be safely committed (10). The present results therefore suggest that stabilization funds are most effective when embedded within a broader framework of credible forecasts, transparent rules, and institutional discipline.

The integrated reform package produced the strongest outcome by combining expenditure efficiency, institutional strengthening, leakage reduction, revenue diversification, and fiscal stabilization. Under this scenario, the average fiscal balance shifted into surplus, the peak post-shock deficit was substantially reduced, the recovery period fell to less than two years, and the fiscal resilience index increased to 84.6. This result indicates that the interaction among reforms is nonlinear and complementary. A stronger institution improves the implementation of performance

budgeting; better information systems improve oversight and forecasting; reduced leakage preserves fiscal space; revenue diversification reduces exposure to oil shocks; and stabilization reserves provide protection during downturns. This finding corresponds with the broader direction of contemporary public financial management research, which increasingly treats accounting, auditing, budgeting, digitalization, and performance measurement as interconnected elements rather than isolated reforms (12, 14, 15, 17). It also supports the argument that public-sector budgeting reform should be systemic rather than fragmented. The Iraqi fiscal system appears unlikely to become resilient through a single technical intervention; resilience emerges when multiple reinforcing vulnerabilities are addressed simultaneously.

Another important interpretation concerns the difference between short-term fiscal consolidation and long-term resilience. The findings showed that simple expenditure compression can improve the budget balance rapidly, but it may produce weaker long-term outcomes if productive capital expenditures are disproportionately reduced. By contrast, institutional and efficiency-oriented reforms may initially generate more gradual improvements but produce stronger cumulative benefits. This distinction is relevant to public budgeting because operational choices concerning the allocation and management of resources influence not only current financial balances but also the capacity of institutions to deliver services over time. Research on operational budgeting has similarly shown that budget decisions are closely connected to institutional expectations and the practical requirements of service delivery (20). The findings therefore suggest that fiscal resilience should not be equated with austerity. A resilient budget must preserve enough flexibility to respond to shocks while maintaining productive expenditure and essential services.

The results also have implications for the relationship between fiscal policy and broader public financial architecture. Off-budget operations and indirect fiscal pressures can weaken the transparency and controllability of government finances, particularly when public-sector borrowing and banking-sector relationships are used to accommodate fiscal imbalances (11). Although the present simulation focused primarily on the formal budgetary system, the finding that fiscal persistence can amplify shocks suggests that off-budget obligations may further increase vulnerability if they are not fully incorporated into fiscal planning. Similarly, accrual-based approaches may improve the visibility of longer-term liabilities and resource use when effectively implemented (12, 13). In this respect, the System Dynamics framework provides a useful foundation for extending future fiscal models beyond cash-based budget flows to include public liabilities, contingent obligations, and other accumulated fiscal pressures.

Overall, the findings support a systemic interpretation of public budgeting reform in Iraq. The study demonstrates that fiscal vulnerability arises from the interaction of oil dependence, recurrent expenditure rigidity, weak institutional capacity, fiscal leakage, and delayed adjustment. At the same time, fiscal resilience can be strengthened through coordinated reforms that modify the feedback structure of the system. The results are consistent with previous research emphasizing performance-based budgeting, organizational readiness, fiscal transparency, forecasting, institutional capacity, digital financial management, and resilience as interconnected components of effective public-sector financial governance (1, 2, 4, 6). The System Dynamics approach adds value by demonstrating how these components interact over time and how policy interventions that appear modest individually can generate substantial improvements when implemented as part of an integrated reform strategy.

The present study has several limitations that should be considered when interpreting its findings. First, the model relies on annual historical data for 2010–2023, which limits the number of observations available for econometric estimation and may reduce the ability to capture short-term fiscal fluctuations occurring within individual

fiscal years. Second, some institutional variables, including corruption-related leakage, administrative efficiency, and political stability, are inherently difficult to measure precisely and may contain measurement error. Third, System Dynamics models necessarily simplify reality by selecting the variables and feedback mechanisms considered most relevant to the research problem, meaning that some potentially important determinants, such as regional fiscal differences, monetary-fiscal interactions, public debt maturity structures, exchange-rate effects, or geopolitical disruptions, were not represented in full detail. Fourth, the results of scenario analysis depend on parameter assumptions and should therefore be interpreted as conditional projections rather than exact predictions. Finally, the expert component was based on purposive selection, which provided specialized knowledge but may not capture the full range of perspectives among all institutions participating in Iraqi public financial management.

Future research should extend the current model by incorporating higher-frequency data where available and by enlarging the historical time horizon to improve parameter estimation and model calibration. Further studies could also integrate public debt dynamics, sovereign borrowing costs, exchange-rate movements, monetary policy, and banking-sector exposure into the System Dynamics structure. Regional or provincial budgeting could be modeled separately to examine whether fiscal resilience differs across Iraqi governorates. Future models may also distinguish more explicitly between recurrent and capital expenditures and estimate how different forms of expenditure affect economic growth, revenue generation, and long-term resilience. Additional research could compare Iraq with other oil-dependent economies to determine which feedback structures are common across resource-dependent fiscal systems and which are specific to Iraq. More sophisticated uncertainty analysis, including Monte Carlo simulation, stochastic oil-price processes, and alternative political-stability trajectories, could also provide a richer assessment of the robustness of different reform packages.

From a practical perspective, policymakers should avoid treating budgeting reform as a sequence of isolated technical interventions and instead adopt an integrated fiscal-resilience strategy. Priority should be given to gradually reducing dependence on oil revenues through sustainable non-oil revenue mobilization while simultaneously improving expenditure efficiency and protecting productive capital investment. Stronger expenditure controls should be combined with performance-based budgeting so that fiscal consolidation focuses on inefficient spending rather than indiscriminate reductions. Institutional capacity should be strengthened through improved financial management information systems, transparent reporting, professional training, digital auditing, and stronger internal controls. Measures to reduce leakage and administrative waste should be incorporated directly into fiscal planning, while multi-year expenditure forecasting should be institutionalized to prevent temporary revenue increases from generating permanent expenditure commitments. Establishing or strengthening a rules-based fiscal stabilization mechanism would further improve the government's ability to absorb oil-revenue shocks, particularly if deposits and withdrawals are governed by transparent and enforceable rules. The strongest practical implication of the study is that fiscal resilience in Iraq is most likely to improve when revenue diversification, expenditure discipline, institutional reform, anti-leakage measures, and stabilization policies are implemented together rather than separately.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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