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Study on the efficiency of financial operation of local institutions and coordinated development of regional economy

Junshuai Guo[1,*], *Jie Fan*[2] *and Luyao Jiao*[2]

[1] School of Urban Economics and Management, Beijing University of Civil Engineering and Architecture, Beijing 102616, Beijing, China
[2] School of International Business, Beijing Foreign Studies University, Beijing 100089, China

SUMMARY: *Under the background of the continuous deepening of financial performance management and the continuous improvement of regional coordinated development, the financial operation efficiency of local public institutions and its economic linkage effect have attracted increasing attention. Focusing on the problem of financial operation efficiency of local public institutions and coordinated development of regional economy, this paper constructs a five-dimensional index system covering capital allocation, budget implementation, asset use, public service output and financial sustainability. It introduces feature coding, adaptive weight learning, time window input and efficiency mapping methods, and establishes a data-driven financial operation efficiency measurement model. Coupled coordination analysis and dynamic prediction method are used to identify regional coordination states. The results show that the Accuracy of the proposed model is 91.8%, the F1-score is 90.9%, the RMSE is only 0.041, and the prediction accuracy of the coupling coordination degree is 89.6%. The coupling coordination degrees of the Yangtze River Delta, the Pearl River Delta and the Beijing-Tianjin-Hebei region are 0.959, 0.954 and 0.946, respectively, and the maximum difference between different time Windows in the robustness test is not more than 0.015. The results show that there is a significant positive correlation between the financial operation efficiency of local institutions and the level of regional economic coordination, and the improvement of financial operation efficiency can provide support for the optimal allocation of financial resources and high-quality coordinated development of regions.*

KEYWORDS: *Local institutions; Financial operation efficiency; Regional economy; Coordinated development*

1 Introduction

Local institutions are important organizations that undertake the supply of public services, the implementation of people's livelihood and the implementation of regional governance. Their financial operation status is not only related to the supply quality of basic public services such as education, medical care, culture and social security, but also directly affects the efficiency of local financial resource allocation and the vitality of regional economy [1]. With the continuous deepening of financial performance management and the continuous embedding of digital governance means into public management practices, the financial operation of local institutions has gradually shifted from a single problem of fund balance to a comprehensive

*15890580214@163.com
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issue of equal emphasis on efficiency identification, structural optimization and collaborative regulation [2, 3]. After the development of regional economy has entered a new stage of parallel structural adjustment and quality improvement, how to identify inefficient links in the allocation of public institutions from the level of financial operation, and then reveal the linkage relationship between them and the quality of regional economic growth, the evolution of industrial structure and the balance of public services, has become an important topic worthy of in-depth discussion [4].

Existing studies mainly focus on the performance of fiscal expenditure, public resource allocation and coordinated development of regional economy, forming a relatively rich analysis basis, but there are still some deficiencies [5, 6]. One kind of research focuses on the comparison of static indicators, which can reflect the characteristics of fiscal operation in a certain period, but it is difficult to describe the dynamic relationship between the change of fiscal efficiency and the response of regional economy. The other kind of studies pay more attention to the scale of macro fiscal expenditure or the economic behavior of local governments, and the identification of fiscal efficiency of public institutions, the micro-operating main body, is still insufficient [7, 8]. At the same time, the efficiency of fiscal operation is affected by multiple factors such as budget implementation, asset utilization, personnel structure, service output and regional economic environment, and the variables are obviously multi-dimensional, non-linear and coupling. If the traditional empirical judgment or linear analysis framework is still mainly relied on, it is often difficult to fully reveal the complex relationship. It is also not conducive to the formation of more explanatory and predictive research conclusions [9, 10].

Based on this, this paper integrates the financial operation efficiency of local institutions and the coordinated development of regional economy into a unified analysis framework, and combines the data-driven method to systematically study the financial operation efficiency measurement, key variable representation and regional coordination relationship. Starting from the financial operation characteristics of local public institutions, this paper constructed the evaluation dimension and key variable system of financial operation efficiency, and introduced the data-driven efficiency measurement model to identify the financial operation state of public institutions in different regions. On this basis, the coupling analysis and forecast method of fiscal operation efficiency and coordinated development of regional economy are further constructed to reveal the correlation mechanism, change trend and influence path between the two. The research in this paper can help to improve the fineness and intelligence level of financial management of local institutions, and also provide methodological support for the optimal allocation of regional financial resources and high-quality collaborative development.

2 Literature Review

Around the relationship between fiscal operation efficiency and regional economic development, domestic and foreign research has formed a more systematic discussion path. Starting from fiscal incentive and growth mechanism, some literatures focus on the internal relationship between income sharing, fiscal incentive, public expenditure and economic growth, and point out that fiscal allocation system and expenditure arrangement will affect regional economic performance through resource allocation, risk sharing and growth incentive [11, 12]. On this basis, the relationship between public sector efficiency and economic growth has gradually become the focus of research. Relevant studies believe that public sector efficiency is not simply reflected in the control of expenditure scale, but also

reflected in the comprehensive improvement of public service supply, governance quality and economic output under the conditions of given financial resources [13]. Studies on government expenditure efficiency have been further extended to the regional and national levels. There are literatures discussing the use effect of government resources from the perspective of the fiscal expenditure efficiency of Latin American countries [14]. There are also studies linking expenditure efficiency with public trust in the country, emphasizing the dual significance of economic effect and governance effect of efficiency improvement [15].

In the aspect of influencing factors of fiscal efficiency, the research perspective is shifting from result evaluation to mechanism identification. Stochastic frontier analysis and other methods have been used to identify the determinants of public sector efficiency, indicating that institutional arrangements, fiscal constraints, governance capacity and external environment all have a significant impact on efficiency performance [16]. The relationship between local government expenditure efficiency and fiscal decentralization is also widely concerned. Relevant studies show that decentralization structure does not necessarily bring efficiency improvement, and its role depends on local fiscal autonomy, responsibility allocation and governance environment [17]. Such results provide an important reference for understanding the financial operation of local public institutions. However, the existing research objects mostly focus on the overall level of local governments, and the subdivision analysis of public institutions, the specific financial execution subject, is still relatively insufficient.

On the coordinated development of regional economy, the existing research is more from the diffusion of innovation, regional convergence and coordinated development effect. Innovation activities have been proved to affect the process of regional economic convergence, and to a certain extent, promote the narrowing of the development gap between regions [18]. The study of provincial heterogeneity convergence shows that the differences in growth path, development foundation and factor endowment of different regions will lead to obvious hierarchical characteristics of regional coordinated development [19]. In relatively backward areas, public expenditure performance dynamics also show significant regional differences and continuous adjustment characteristics [20]. At the same time, the study on the relationship between fiscal rule reform, system quality, fiscal decentralization and public service supply further pointed out that the optimization of fiscal system and the improvement of governance quality can enhance local development ability and regional coordination level by improving expenditure efficiency [21-23]. From a more comprehensive perspective, regional coordinated development will also reflect its external comprehensive effect through ecological improvement and public welfare enhancement [24], and local budget structure and fiscal autonomy constitute an important foundation affecting local financial sustainability and governance efficiency [25].

In general, the existing research provides strong support for the analysis of the relationship between fiscal efficiency and regional economic development, but there are still three shortcomings: first, the research focuses on the overall expenditure efficiency of local governments, and does not pay enough attention to the financial operation efficiency of local public institutions. Second, the existing results are mostly carried out from the single dimension of fiscal efficiency or regional development, and the discussion on the coupling mechanism, co-evolution and prediction analysis of the two is insufficient. Third, in terms of research methods, there are many traditional econometric analysis methods, and there is still room for expanding the application of data-driven methods for multi-dimensional variable association identification and complex relationship characterization. Based on this, this paper intends to incorporate the measurement of fiscal operation efficiency of local institutions and the analysis of coordinated development of regional economy into a unified framework on the

basis of existing research, so as to improve the systematicity and explanatory power of the research.

3 Construction of measurement model of financial operation efficiency of local institutions and coordinated development of regional economy

3.1 Construction of evaluation dimensions and characterization of key variables of financial operation efficiency of local public institutions

The financial operation efficiency of local public institutions cannot be simply understood as the level of income and expenditure balance, but should be defined as the ability of the unit to maximize its comprehensive performance in terms of capital allocation, budget implementation, asset utilization, public service output and continuous operation guarantee under the constraints of established financial resources. From the perspective of operation mechanism, the local public institutions are connected with the process of financial fund input and budget management at one end, and the supply results of public services such as education, medical care, culture and social security at the other end. Their efficiency is not only affected by the internal resource organization mode, but also restricted by the level of regional economic development, the degree of population agglomeration and the intensity of public demand. Therefore, this study divides the fiscal operation efficiency into five first-class dimensions: capital allocation efficiency, budget implementation efficiency, asset use efficiency, public service output efficiency and fiscal sustainability, and builds an evaluation framework with input-process-output-guarantee logic.

In the key variable representation, the fiscal operation efficiency index should reflect both the static level and the dynamic change. In order to ensure the comparability of different dimension indexes, the original variables are first homogenized and interval standardized. After the unified conversion of the forward index and the reverse index, the standardized result is denoted as z_{ij}:

$$z_{ij} = \begin{cases} \dfrac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}, & j \in J^{+} \\ \dfrac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)}, & j \in J^{-} \end{cases} \tag{1}$$

Here, x_{ij} represents the observation value of the ith institution on the JTH index, and J^{+} and J^{-} represent the set of positive and reverse indicators, respectively. After processing, the values of each index are compressed to the interval [0,1], which is convenient for subsequent dimension synthesis and model input.

Considering that the state of fiscal operation has obvious time continuity, only relying on cross-sectional values is still not enough to reveal the trend of efficiency change, so the dynamic change intensity of variables g_{ij}^{t} is further introduced:

$$g_{ij}^{t} = \ln\left(\frac{x_{ij}^{t} + \varepsilon}{x_{ij}^{t-1} + \varepsilon}\right) \tag{2}$$

Here, x_{ij}^{t} and x_{ij}^{t-1} represent the index values of two adjacent periods, respectively, and ε

is a minimal constant set to avoid failure of the denominator or log term. This formula can describe the marginal change direction of budget completion rate, asset utilization rate, unit service cost and other indicators, and provide a basis for subsequent judgment of whether the fiscal operation is in the state of improvement, fluctuation or contraction.

At the dimension level, in order to take into account the static level and dynamic changes, this study further aggregated the individual index representation values into the dimension score $d_i^{(k)}$:

$$d_i^{(k)} = \sum_{j=1}^{m_k} \omega_j^{(k)} z_{ij}^t (1 + \lambda g_{ij}^t) \tag{3}$$

where m_k represents the number of indicators in the KTH dimension, $\omega_j^{(k)}$ represents the weight of the JTH indicator in the dimension, and λ is the dynamic adjustment coefficient. In this way, a certain dimension can not only reflect the current level of fiscal operation, but also absorb the recent trend of change, so as to enhance the explanatory power of the evaluation results for the linkage analysis of regional economy.

In order to make the evaluation framework more intuitive, the dimension composition of the evaluation of financial operation efficiency of local institutions is shown in Figure 1.

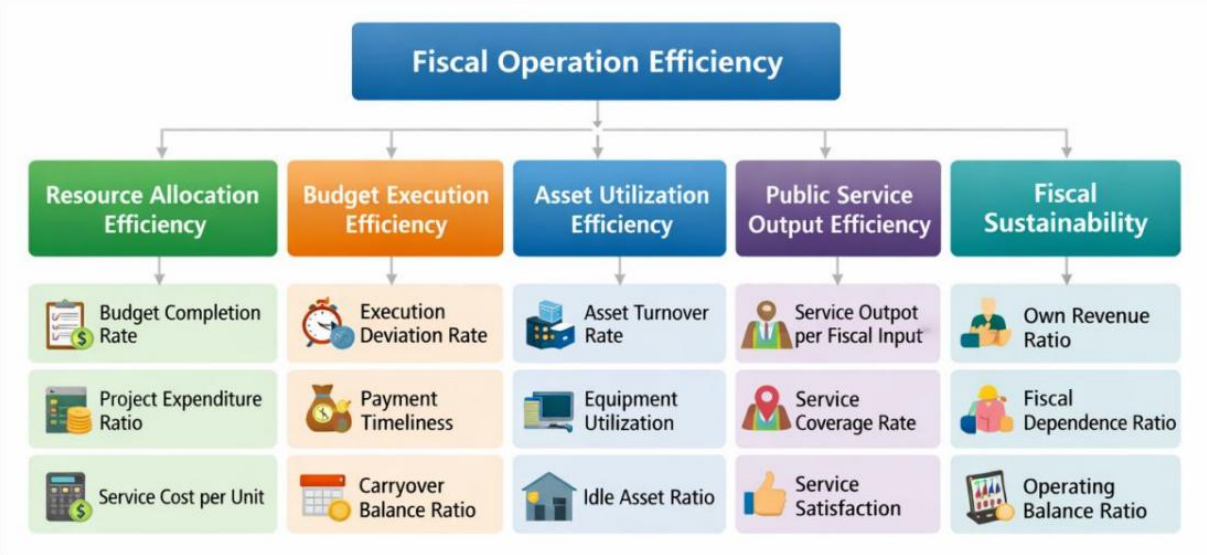

Figure 1: Dimension composition chart of financial operation efficiency evaluation of local institutions

Figure 1 decomposes the fiscal operation efficiency into five first-level dimensions, and unfolds along the logic of "resource input-execution process-asset transformation -service output -continuous guarantee", which can better cover the core links of the fiscal operation of local public institutions, and also provides a clear structure for the characteristic organization in the subsequent measurement model.

Based on the above analysis, the evaluation dimensions and index system of fiscal operation efficiency of local institutions are shown in Table 1.

Table 1: Evaluation dimensions and index system of fiscal operation efficiency of local public institutions

Primary Dimension	Secondary Indicator	Attribute	Representation Meaning
Funding Allocation Efficiency	Budget Completion Rate	+	Reflects the degree to which annual fiscal funds are implemented and allocated as planned
Funding Allocation Efficiency	Proportion of Project Expenditure	+	Reflects the concentration of fund allocation toward business development and public service provision
Funding Allocation Efficiency	Unit Service Cost	-	Reflects the cost consumption level of public service provision per unit
Budget Execution Efficiency	Budget Deviation Rate	-	Reflects the extent to which actual budget execution deviates from planned targets
Budget Execution Efficiency	Timeliness Rate of Centralized Payment	+	Reflects the efficiency of fiscal fund disbursement and execution
Budget Execution Efficiency	Carryover and Surplus Rate	-	Reflects the extent of fund accumulation and lagged utilization
Asset Utilization Efficiency	Asset Turnover Rate	+	Reflects the efficiency with which existing assets are transformed into service capacity
Asset Utilization Efficiency	Equipment Utilization Rate	+	Reflects the actual operating level of facilities and equipment
Asset Utilization Efficiency	Proportion of Idle Assets	-	Reflects the degree of redundant allocation and inefficient occupation of assets
Public Service Output Efficiency	Service Output per Unit of Fiscal Input	+	Reflects the ability to convert fiscal input into public service output
Public Service Output Efficiency	Service Coverage Rate	+	Reflects the scope and accessibility of public services
Public Service Output Efficiency	Service Satisfaction	+	Reflects service quality and public perception
Fiscal Sustainability Capacity	Proportion of Own-Source Revenue	+	Reflects the endogenous support capacity of the institution’s revenue sources
Fiscal Sustainability Capacity	Fiscal Dependency Degree	-	Reflects the degree of dependence on external fiscal support
Fiscal Sustainability Capacity	Operating Surplus Rate	+	Reflects the stability and buffering capacity of fiscal operation

Table 1 has 5 first-level dimensions and 15 second-level indicators, including 10 positive indicators and 5 reverse indicators, covering not only fiscal input, budget implementation, asset utilization and public service output, but also sustainable variables reflecting long-term operation stability. The index system can completely characterize the structural characteristics of the financial operation efficiency of local public institutions and provide a standardized input basis for the construction of data-driven measurement model in Section 3.2.

3.2 Construction of data-driven measurement model of financial operation efficiency of local public institutions

After completing the construction of fiscal operation efficiency evaluation dimensions and the characterization of key variables, it is necessary to further transform the multi-dimensional indicators into comparable, orderable and interpretable comprehensive efficiency results. Although traditional methods based on manual weighting or single ratio calculation can reflect the state of fiscal operation to a certain extent, their ability to identify complex information such as budget implementation fluctuations, asset use differences, and nonlinear changes in public service output is still limited. In order to enhance the ability of the measurement results to describe the real financial operation state, this paper constructs a data-driven financial operation efficiency measurement model, inputs the standardized multi-dimensional indicators into the feature coding layer, and realizes the comprehensive output of the financial operation efficiency score of local institutions through weight learning and efficiency mapping.

Let the index input matrix formed by the ith local institution in the time series window T be Xi. Its structure can be expressed as follows:

$$X_i = \begin{bmatrix} z_{i1}^1 & z_{i2}^1 & \cdots & z_{im}^1 \\ z_{i1}^2 & z_{i2}^2 & \cdots & z_{im}^2 \\ \vdots & \vdots & \ddots & \vdots \\ z_{i1}^T & z_{i2}^T & \cdots & z_{im}^T \end{bmatrix} \in \mathbb{R}^{T\times m} \tag{4}$$

Here, m represents the total number of indicators. Compared with the single-period input, the time series window structure can retain the fluctuation characteristics of fiscal operation in different stages, so that the model can not only identify the "current efficiency level", but also identify the "efficiency evolution direction".

In the feature extraction step, this paper uses the nonlinear coding method to map the original index to the low-dimensional representation space, and obtains the implicit feature vector hi of fiscal operation:

$$h_i = \phi(W_e \mathrm{vec}(X_i) + b_e) \tag{5}$$

where, $\mathrm{vec}(X_i)$ represents the column-wise expansion vector of the input matrix, W_e and b_e are the parameter matrix and bias term of the coding layer, respectively, and $\phi(\cdot)$ is the activation function. The central role of this step lies in compressing redundant information and extracting potential association patterns between budget execution, service output and asset utilization.

Since the influence degree of different indicators on fiscal operation efficiency is not consistent, this paper further introduces the weight learning mechanism to allocate the importance of hidden features. Let the feature weight vector be a_i, then:

$$a_i = \mathrm{softmax}(W_a h_i + b_a) \tag{6}$$

On this basis, the weighted key representation vector ri is constructed as follows.

$$r_i = a_i \odot h_i \tag{7}$$

Here, $\odot$ denotes element-wise product. Through this process, the model can automatically improve the attention of core variables such as budget completion rate, payment

timely rate, and output per unit input service, and reduce the interference of weak explanatory variables on the comprehensive evaluation.

Considering that the efficiency of fiscal operation is essentially reflected in the output transformation ability under input constraints, this paper further maps the weighted characteristics into "input pressure" and "output performance". Let input intensity be I_i and output capacity be Oi, then they are respectively defined as follows:

$$I_i = \sum_{j=1}^{p} \beta_j r_{ij}, O_i = \sum_{j=1}^{q} \gamma_j r_{ij} \tag{8}$$

Here, β_j and γ_j represent the mapping coefficients of input and output features, respectively, and p and q represent the number of dimensions of input and output items, respectively. Thus, the original efficiency value of financial operation of local institutions can be constructed as follows:

$$F_i = \frac{O_i}{I_i + \delta} \tag{9}$$

Here, δ is a smoothing term set to prevent the denominator from being too small. This formula can reflect the efficiency essence of "achieving higher public service output with less financial consumption".

In order to facilitate the horizontal comparison between different regions and different types of institutions, this paper further compresses the original efficiency value to the range of [0,1], and obtains the final financial operation efficiency score S_i:

$$S_i = \frac{1}{1 + \exp\{-\kappa(F_i - \tau)\}} \tag{10}$$

Here, κ denotes the distribution stretch coefficient and τ denotes the demarcation threshold. After mapping, the score is closer to 1, indicating that the financial operation efficiency of local institutions is higher. The closer it is to 0, the more obvious inefficiency characteristics exist in terms of capital allocation, budget implementation or service output transformation.

In order to ensure the expression stability of the model in the training process, this paper introduces reconstruction constraints and parameter regularization terms to construct the objective function:

$$\mathcal{L} = \frac{1}{n} \sum_{i=1}^{n} \| x_i - \hat{x}_i \|_2^2 + \eta \|\Theta\|_2^2 \tag{11}$$

where $\hat{x}_i$ is the model reconstruction result, Θ is the set of all parameters to be learned, η is the regularization coefficient. On the one hand, this objective function requires the model to retain the structural information of the original financial indicators as much as possible, on the other hand, it suppresses the excessive fluctuation of the parameters and improves the robustness of the efficiency measure results.

Based on the above construction ideas, the framework of the fiscal operation efficiency measurement model based on data-driven is shown in Figure 2.

Figure 2: Framework diagram of financial operation efficiency measure model based on data-driven

Figure 2 shows the core modules of the fiscal operation efficiency measure model from the overall structure. Based on the above five evaluation dimensions as input, the model achieves comprehensive score output through sequential organization, nonlinear coding, weight learning and efficiency mapping, which can better adapt to the characteristics of multi-dimensional, heterogeneous and dynamic changes of financial operation indicators of local public institutions. In the specific implementation process, the financial operation efficiency measurement process is shown in Figure 3.

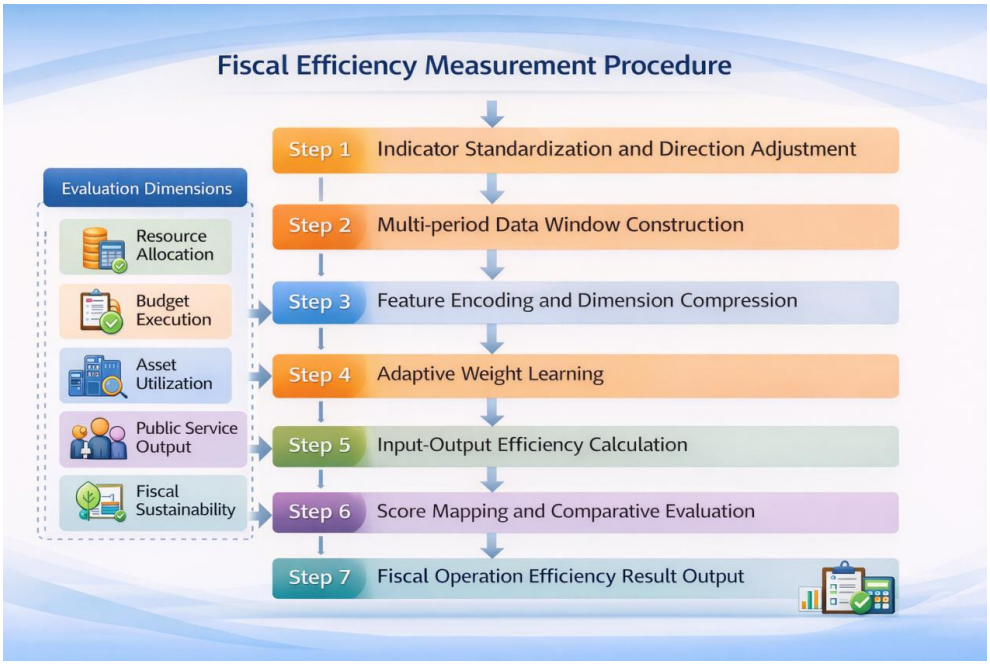

Figure 3: Flow chart of financial operation efficiency measure

Figure 3 further shows the operation process of the model: firstly, the index homogenization and standardization are completed, and then the multi-period window data are organized, and then the feature coding and weight learning are carried out, and the fiscal operation efficiency score is generated on the basis of input-output mapping. This process not only retains the focus on the nature of efficiency in economic management research, but also incorporates the advantages of data-driven methods in complex indicator identification, which can provide methodological support for the subsequent model performance evaluation and empirical result analysis in Chapter 4.

3.3 Coupling analysis and prediction method of fiscal operation efficiency and coordinated development of regional economy

The financial operation efficiency of local public institutions is not an isolated management result, but a continuous interactive relationship with regional economic development level, industrial structure evolution, public service supply capacity and factor flow efficiency. Greater efficiency in fiscal operations will lead to more precise allocation of government funds, smoother budget implementation, and more stable public service output, which will help improve the regional business environment, enhance human capital accumulation, and enhance the carrying capacity of industries. After the quality of regional economic development is improved, the financial operation foundation of public institutions will be inversely improved through the expansion of tax sources, demand growth, innovation diffusion and factor agglomeration. Therefore, on the basis of the above financial operation efficiency measurement results, this paper brings the financial operation efficiency subsystem and the regional economic development subsystem into a unified framework, and constructs a coupling analysis and dynamic prediction method to identify the coordination degree and evolution trend between the two. Figure 4 shows the coupling mechanism of fiscal operation efficiency and coordinated development of regional economy.

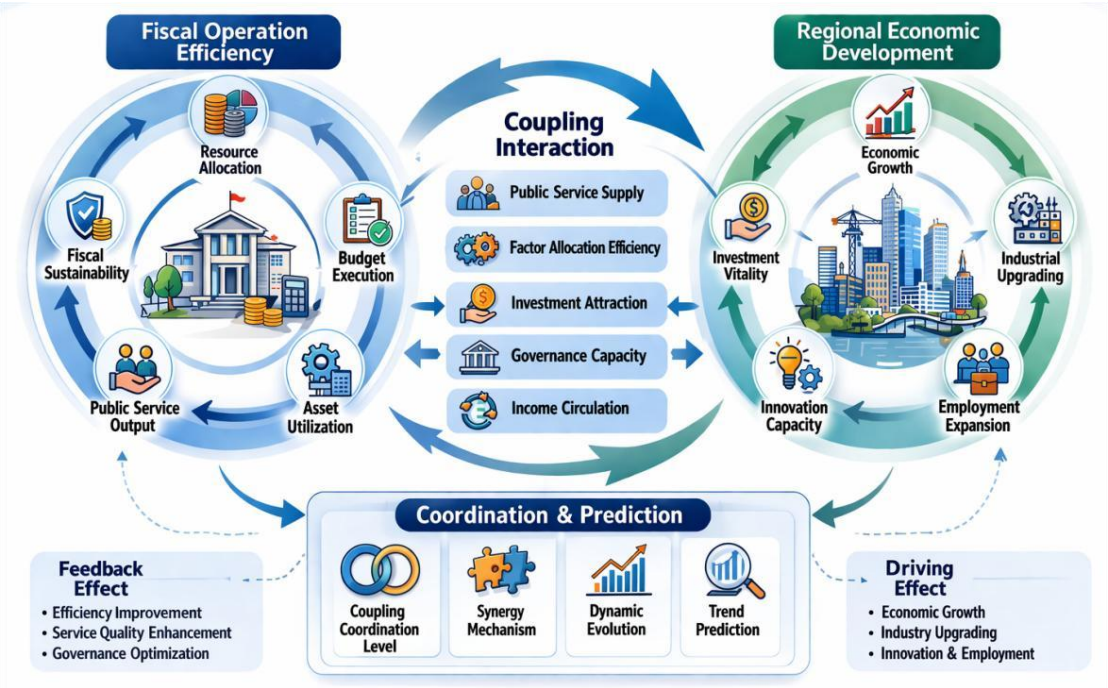

Figure 4: Coupling mechanism diagram of fiscal operation efficiency and coordinated development of regional economy

Figure 4 shows that the financial operation efficiency of local public institutions plays a role in regional economic growth through public service supply, resource allocation optimization and governance capacity improvement, while the regional economic development plays a reverse role in the financial operation system through the expansion of financial base, upgrading of demand structure and enhancement of innovation ability. The two show the characteristics of two-way linkage and mutual strengthening of collaborative evolution. Based on this mechanism, the fiscal operation efficiency score obtained in Section 3.2 is denoted as S_it, and the regional economic development composite index R_it is constructed.

In order to improve the stability of the comprehensive representation of regional economic indicators, this paper uses the weighted geometric aggregation method to describe the regional economic development level:

$$R_i^t = \prod_{k=1}^{q} (y_{ik}^t + \xi)^{\alpha_k} \tag{12}$$

Here, y_{ik}^t represents the standardized value of the KTH regional economic indicator in the ith region in period t, α_k represents the corresponding weight, and ξ is the smoothing term. Compared with the simple linear sum, this formula can better reflect the synergistic compensation relationship between economic growth, industrial upgrading, employment absorption, investment vitality and innovation ability.

After obtaining the financial operation efficiency subsystem index S_i^t and the regional economic development subsystem index R_i^t, this paper uses the symmetric coupling function to measure the interaction strength between them:

$$C_i^t = \frac{2\sqrt{S_i^t R_i^t}}{S_i^t + R_i^t} \tag{13}$$

where, the closer C_i^t is to 1, the closer the linkage between fiscal operation efficiency and regional economic development is. The closer it is to 0, it means that the two are weakly associated and there is an obvious separation phenomenon. Considering that high coupling does not necessarily mean high coordination, it is still necessary to further introduce the term of comprehensive development level:

$$T_i^t = \mu S_i^t + \nu R_i^t, \quad \mu + \nu = 1 \tag{14}$$

Among them, μ and ν respectively represent the contribution coefficients of fiscal operation efficiency and regional economic development in the comprehensive coordination evaluation. Based on this, the coupling coordination degree D_i^t is constructed as follows.

$$D_i^t = \sqrt{C_i^t \cdot T_i^t} \tag{15}$$

This index reflects the system interaction intensity and comprehensive development quality at the same time, and can avoid the interference of "low level and high coupling" on the judgment results. It is more suitable for the empirical identification of the financial operation efficiency of local public institutions and the coordinated development of regional economy.

Considering the significant spatial correlation and time continuation characteristics of regional development, it is difficult to describe the future change trend only by the current coupling coordination degree. Therefore, this paper further introduces the cooperative spillover term and historical evolution term of neighboring areas to construct the dynamic prediction expression:

$$\widehat{D}_i^{t+1} = \lambda_1 D_i^t + \lambda_2 \sum_{j=1}^{n} w_{ij} D_j^t + \lambda_3 (D_i^t - D_i^{t-1}) \quad (16)$$

where, $\widehat{D}_i^{t+1}$ represents the predicted value of coupling coordination degree in the next period, w_{ij} represents the weight of regional adjacency or economic connection, and λ_1, λ_2, and λ_3 represent the influence coefficients of current state continuation effect, spatial spillover effect, and trend inertia effect respectively. This method not only retains the endogenous evolution information of the local fiscal and economic coupling, but also absorbs the external transmission influence of the coordinated development of the surrounding regions, which is more conducive to improving the realistic interpretation power of the prediction results. The coupling coordination degree grading criteria are shown in Table 2.

Table 2: Table of coupling coordination degree grading criteria

Coupling Coordination Degree Interval	Coordination Type	Status Description
0.00–0.30	Low-Level Imbalance	Fiscal operation efficiency is clearly disconnected from regional economic development, and the foundation for coordination is weak.
0.30–0.50	Mild Imbalance	The two systems show a certain degree of connection, but their interaction is insufficient and the efficiency of resource transmission remains low.
0.50–0.70	Basic Coordination	Fiscal operation and regional economy can support each other, and an initial coordinated relationship has taken shape.
0.70–0.90	Good Coordination	The two systems interact smoothly, and improvements in fiscal efficiency exert a relatively strong driving effect on regional economic development.
0.90–1.00	High-Level Coordination	Fiscal operation efficiency and regional economic development have formed a high-level state of coordinated resonance.

Table 2 divides the coupling coordination degree into five levels, which can provide a unified standard for subsequent regional horizontal comparison, time series tracking and type identification. Based on the classification results, Chapter 4 can not only analyze the differences between the fiscal operation efficiency of local institutions and the coordination level of regional economic development in different regions, but also further judge the evolution direction of the coordination state by combining the predicted value, providing a quantitative basis for the optimal allocation of financial resources and the choice of regional high-quality development path.

4 Analysis of financial operation efficiency of local institutions and coordinated development of regional economy

4.1 Model performance evaluation for financial operation efficiency measures

In order to verify the effectiveness of the data-driven financial operation efficiency measurement model constructed in this paper, entropy method, DEA, random forest and BP neural network are selected as comparison methods, and the performance evaluation is carried out from two levels of measurement accuracy and training stability. Figure 5 shows the comparison of the accuracy of fiscal operation efficiency measures of different models.

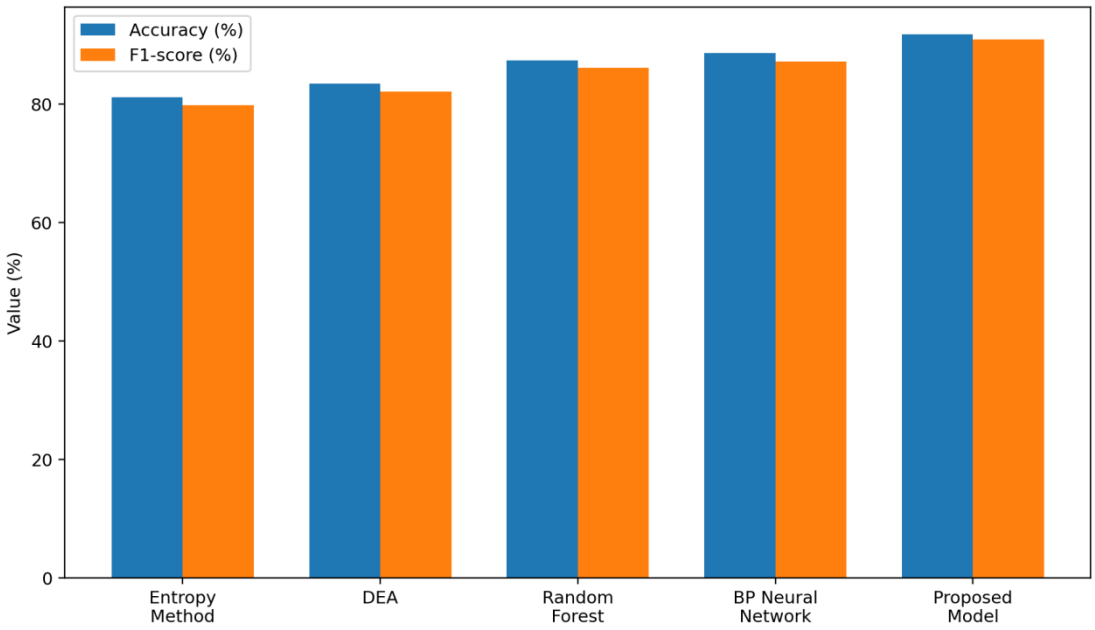

Figure 5: Bar charts comparing the accuracy of different model measures

As can be seen from Figure 5, the proposed model performs best in the main evaluation indicators, with Accuracy reaching 91.8% and F1-score reaching 90.9%, which are significantly better than the 81.2% and 79.8% of entropy method, and higher than the 83.5% and 82.1% of DEA. Compared with random forest and BP neural network, the proposed model improves the Accuracy by 4.4 and 3.2 percentage points respectively, and improves the F1-score by 4.8 and 3.7 percentage points respectively. This shows that in the face of the coexistence of multi-dimensional indicators, strong variable correlation and prominent nonlinear characteristics in the evaluation of financial operation efficiency, the proposed model can more effectively identify the structural relationship between the key features, avoid the information loss problem in the index compression and weight allocation of the traditional method, so as to improve the accuracy and discrimination of the measurement results. In general, the model in this paper shows stronger comprehensive recognition ability in the comparison of different methods, and provides a more reliable quantitative basis for the subsequent analysis of the synergy between fiscal operation efficiency and regional economy.

In addition to the accuracy of the measure, the convergence performance of the model

training process is also an important basis for judging its usability. The model training loss convergence curve is shown in Figure 6.

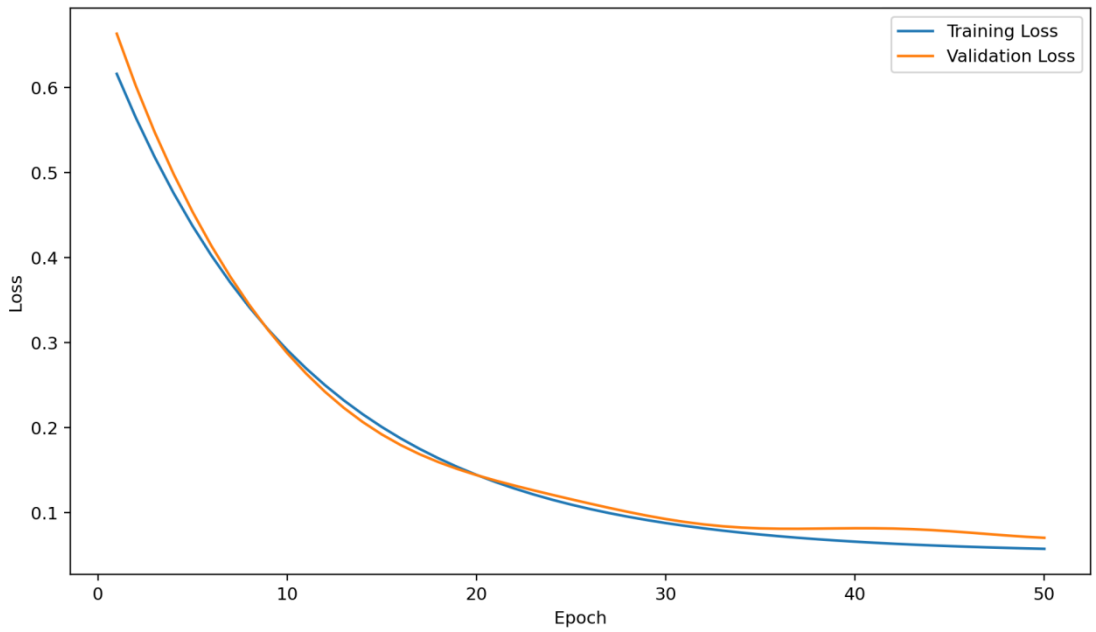

Figure 6: Model training loss convergence plot

It can be seen from Figure 6 that both training loss and validation loss continue to decrease with the increase of iteration rounds, and gradually level off in the later stage. The training loss decreases from 0.616 in the initial stage to 0.057 in the 50th round, and the validation loss decreases from 0.663 to 0.070. In the 10th round, the two have been reduced to 0.291 and 0.288 respectively, and further reduced to 0.088 and 0.092 in the 30th round, indicating that the model can complete the main parameter learning in the middle and early stage, and only a small adjustment and stable optimization are carried out in the later stage. At the same time, the gap between the training loss and the validation loss is always small, and there is no obvious rebound in the later stage, which indicates that the model does not have significant overfitting phenomenon, and the overall training process has good stability and generalization ability. Combined with the results in Figure 5 and Figure 6, it can be believed that the measurement model of fiscal operation efficiency constructed in this paper is not only superior to common comparison methods in accuracy, but also has strong advantages in training convergence speed and result stability, which can better support the subsequent empirical analysis of fiscal operation efficiency of local institutions.

4.2 Analysis of financial operation efficiency of local institutions and coordinated development of regional economy

In order to further identify the different characteristics of the fiscal operation efficiency of local institutions in different regions and the coordinated development of regional economy, this paper comprehensively measured the fiscal operation efficiency, regional economic development index and coupling coordination degree of different regional samples based on the measurement results of fiscal operation efficiency. Table 3 shows the measurement results of the financial operation efficiency of local institutions in different regions and the degree of regional economic synergy.

Table 3: Measurement results of financial operation efficiency of local institutions and regional economic coordination degree in different regions

Region	Fiscal Operation Efficiency	Regional Economic Development Index	Coupling Coordination Degree	Coordination Type
Beijing–Tianjin–Hebei Region	0.890	0.900	0.946	High-Level Coordination
Yangtze River Delta Region	0.910	0.930	0.959	High-Level Coordination
Pearl River Delta Region	0.900	0.920	0.954	High-Level Coordination
Shandong Peninsula Region	0.820	0.780	0.894	Good Coordination
Central Plains Region	0.740	0.710	0.851	Good Coordination
Middle Reaches of the Yangtze River Region	0.720	0.690	0.840	Good Coordination
Chengdu–Chongqing Region	0.680	0.660	0.819	Good Coordination
Guanzhong Plain Region	0.610	0.580	0.771	Good Coordination
Beibu Gulf Region	0.570	0.550	0.748	Good Coordination
Central-Southern Liaoning Region	0.530	0.500	0.718	Good Coordination
Harbin–Changchun Region	0.490	0.470	0.693	Basic Coordination
Northern Resource-Based Region	0.450	0.430	0.663	Basic Coordination

It can be seen from Table 3 that the fiscal operation efficiency of local institutions and the coordinated development of regional economy show obvious regional gradient differences. The coupling coordination degree of the Yangtze River Delta, the Pearl River Delta and the Beijing-Tianjin-Hebei region reached 0.959, 0.954 and 0.946, respectively, indicating that the financial operation efficiency of local public institutions can be more smoothly translated into regional development momentum in regions with stronger economic foundation, better public service system and higher financial security capacity. In contrast, the coupling coordination degree of Harchang-Yangtze region and northern resource-based regions is 0.693 and 0.663, respectively, which is only at the basic coordination level, reflecting that there is still a certain lag between the improvement of fiscal operation efficiency and the transformation effect of regional economy. In general, the coordination level of the eastern region is significantly ahead, the central and western regions are mostly in the stage of good coordination, and the Northeast and resource-based regions show strong demand for strengthening weak links.

In order to intuitively show the correlation between the efficiency of fiscal operation and the coordinated development of regional economy, the relationship between the efficiency of fiscal operation and the coordinated development of regional economy is shown in Figure 7.

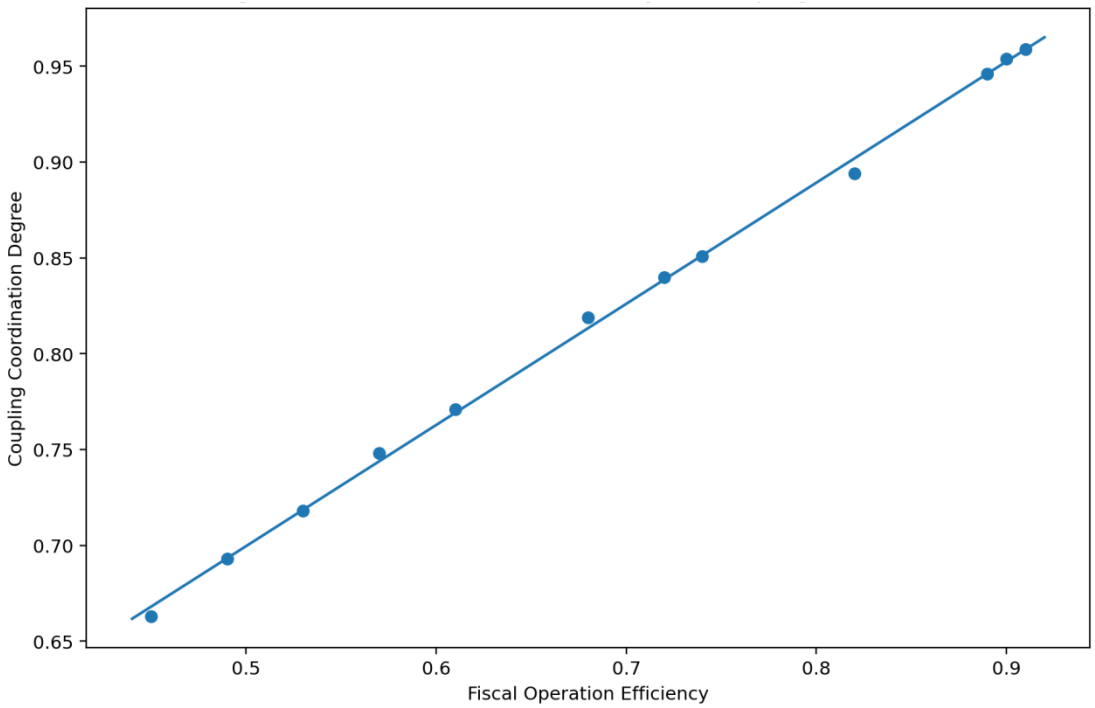

Figure 7: Scatter plot of the relationship between fiscal operation efficiency and regional economic synergy

As can be seen from Figure 7, the overall distribution of sample points is along the upper right direction. The higher the fiscal operation efficiency is, the higher the coupling coordination degree is, indicating that there is an obvious positive correlation between the two. When the fiscal operation efficiency increases from 0.450 to 0.910, the coupling coordination degree also increases from 0.663 to 0.959, an increase of 0.296. This shows that the efficiency improvement of local institutions in budget implementation, asset utilization and public service output can effectively enhance the carrying capacity of regional economic development and the efficiency of resource allocation, so as to promote the continuous improvement of the coordination level. At the same time, the scatter distribution also shows that different regions will still have some differences under the similar level of fiscal operation efficiency, which means that regional economic foundation, industrial structure and governance environment will still have a regulating effect on the coordinated development results.

From the regional structure level, the distribution of coordinated development types in different regions is shown in Figure 8.

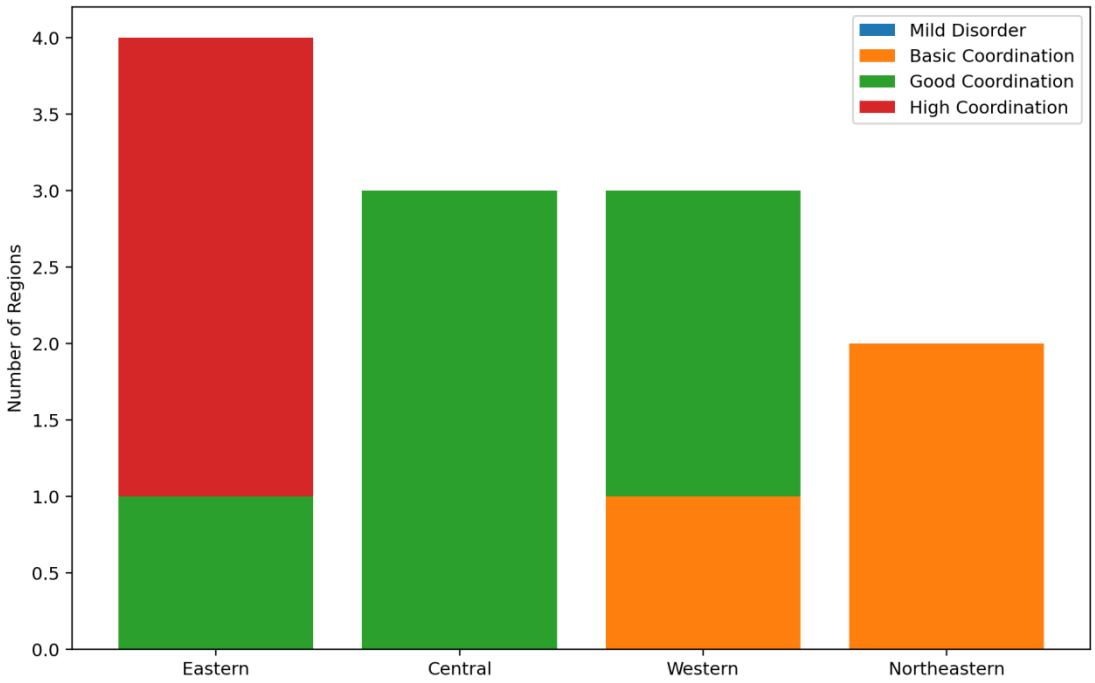

Figure 8: Distribution map of collaborative development types in different regions

Figure 8 shows that the eastern region is dominated by high-level coordination, with 3 out of 4 samples in high coordination and 1 in good coordination. All the three samples in the central region were in good coordination. In the western region, there are 1 basic coordination and 2 good coordination. The two samples in Northeast China are in basic coordination. This shows that the financial operation efficiency of local institutions and the coordinated development of regional economy have formed a relatively clear hierarchical pattern, in which the coordination level is the highest in the eastern region, and the internal structure of the region is more stable. Although the central and western regions have formed a certain foundation for linkage, there is still room for further improvement. The type of coordination in Northeast China is relatively concentrated in the lower level, indicating that the channel from the improvement of fiscal efficiency to the regional development advantage still needs to be unclog continuously. On the whole, the financial operation efficiency of local public institutions has become an important variable affecting the coordinated development of regional economy, and the coordinated differences between regions also provide a realistic basis for the subsequent robustness test and optimization path analysis.

4.3 Reliability and robustness analysis of empirical results

In order to test whether the above empirical results are stable and reproducible, this paper carries out robustness analysis from two aspects: time window variation and parameter perturbation. On the one hand, considering the obvious time accumulation characteristics of fiscal operation efficiency and coordinated development of regional economy, different time window Settings may affect the measurement results of coupling coordination degree. On the other hand, the changes of parameters such as dynamic adjustment coefficient, time window length and learning rate in the model may also cause fluctuations in the results. Therefore, it is necessary to further investigate whether the efficiency of fiscal operation and the coordinated development of regional economy are still basically consistent under different setting conditions. Figure 9 shows the variation curves of coupling coordination degree under

different time Windows.

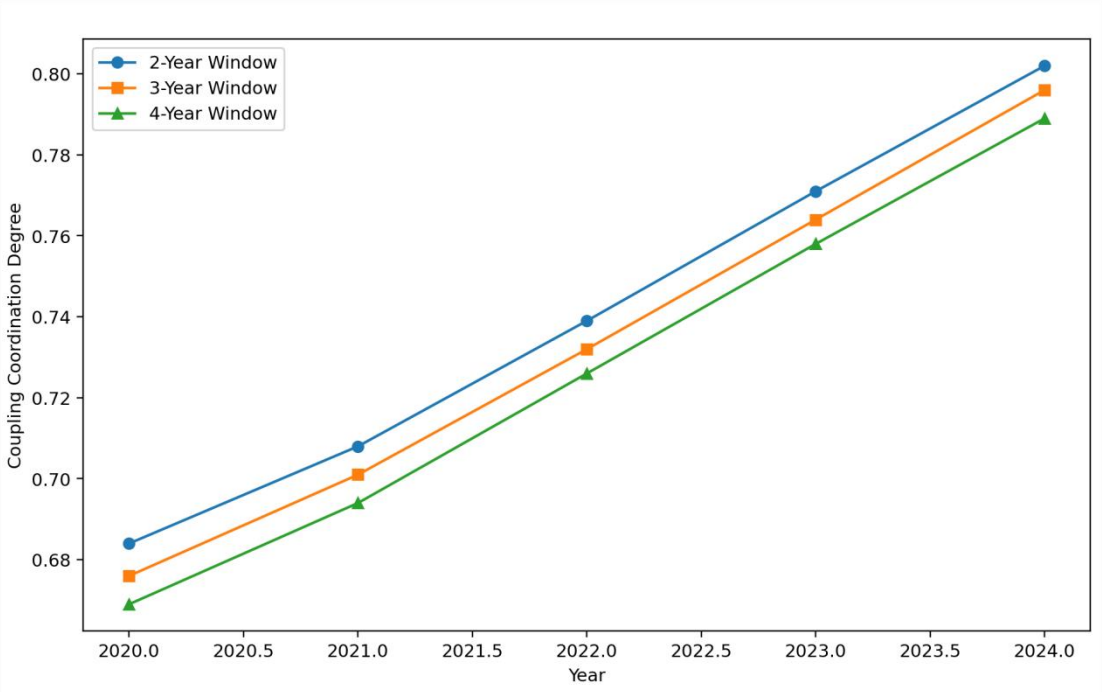

Figure 9: Graph of coupling coordination degree variation under different time Windows

It can be seen from Figure 9 that under the three time window Settings of 2 years, 3 years and 4 years, the coupling coordination degree shows a continuous upward trend, indicating that the linkage relationship between the financial operation efficiency of local institutions and the coordinated development of regional economy has strong time stability. Taking the 2024 results as an example, the coupling coordination degrees under the 2-year window, 3-year window and 4-year window are 0.802, 0.796 and 0.789, respectively, and the maximum difference among the three is only 0.013. In the initial period of 2020, the corresponding values are 0.684, 0.676 and 0.669, respectively, and the maximum difference is 0.015. At the same time, the overall change direction under each window setting remains consistent, showing a gradual transition from medium coordination to high coordination level, indicating that the judgment of the improvement of regional coordination relationship does not depend on a single time setting and has good trend robustness.

In addition to the time window, the model parameter setting is also an important factor affecting the reliability of the results. The fluctuation of model results under different parameter Settings is shown in Figure 10.

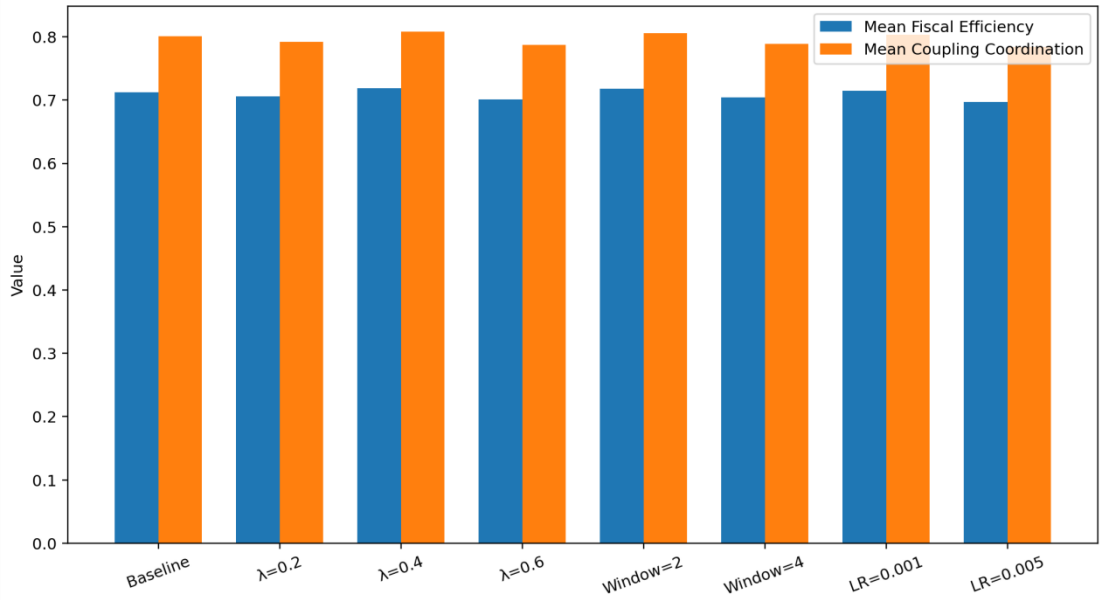

Figure 10: Fluctuation plots of model results for different parameter Settings

It can be seen from Figure 10 that under different dynamic adjustment coefficient, time window length and learning rate setting, the mean value of fiscal operation efficiency and the mean value of coupling coordination degree have a small fluctuation, but the overall change range is limited. Taking the benchmark scheme as a reference, the average value of fiscal operation efficiency is 0.712, and the adjusted range of the parameters is between 0.697 and 0.719, and the maximum fluctuation range is 0.022. The average of coupling coordination degree is 0.801, and the adjusted interval is between 0.784 and 0.808, and the maximum fluctuation range is 0.024. Among them, when the parameter is set as λ=0.4, the model results are relatively optimal, and the mean value of fiscal operation efficiency and coupling coordination degree reach 0.719 and 0.808 respectively. When the learning rate is increased to 0.005, the results decrease slightly but remain at a high level of 0.697 and 0.784. Based on Figure 9 and Figure 10, it can be concluded that the fiscal operation efficiency measure and collaborative analysis method constructed in this paper are not sensitive to the change of time window and key parameters, and the overall empirical conclusion has strong reliability and robustness, which provides a credible basis for subsequent ablation experiments and policy interpretation.

4.4 Ablation experiments

In order to further identify the actual contribution of each key module of the proposed model to the fiscal operation efficiency measure and the collaborative analysis results of regional economy, this paper sets up an ablation experiment to remove the feature coding module, the adaptive weight learning module, the time window input module and the coupling prediction module respectively, and compares them with the full model. The evaluation indicators include the accuracy of financial operation efficiency measure, F1-score, RMSE and the prediction accuracy of coupling coordination degree. The results of ablation experiments are shown in Table 4.

Table 4: Comparison table of ablation experiment results

Model Configuration	Accuracy / %	F1-score / %	RMSE	Coupling Coordination Degree Prediction Accuracy / %
Full Model	91.8	90.9	0.041	89.6
Without Feature Encoding Module	87.1	86.2	0.063	84.3
Without Weight Learning Module	88.0	87.1	0.058	85.2
Without Time-Window Input Module	86.4	85.6	0.067	83.7
Without Coupling Prediction Module	89.2	88.4	0.052	82.9

It can be seen from Table 4 that the complete model achieves the best results in all indicators, with an Accuracy of 91.8%, F1-score of 90.9%, RMSE of only 0.041, and prediction accuracy of coupling coordination degree of 89.6%. When the feature coding module is removed, the Accuracy decreases by 4.7 percentage points, and the RMSE rises to 0.063, indicating that the potential structural relationship in the multi-dimensional financial indicators is difficult to be fully extracted, and the stability of the measurement results is significantly weakened. After removing the weight learning module, the Accuracy and F1-score decrease to 88.0% and 87.1%, respectively, indicating that the adaptive allocation of different index contributions has a direct effect on improving the recognition ability of the model. After removing the time window input module, the decline is the most obvious, the Accuracy drops to 86.4%, and the prediction accuracy of coupling coordination degree drops to 83.7%, indicating that the relationship between fiscal operation efficiency and regional economic coordination has significant time series accumulation characteristics, and the static input is difficult to completely reflect its evolution process. After removing the coupling prediction module, although the results of fiscal operation efficiency measure still maintain a high level, the prediction accuracy of coupling coordination degree drops to 82.9%, which is 6.7 percentage points lower than that of the full model, indicating that the module is of great significance for regional coordination trend identification. In general, the four core modules all play a positive role in improving the performance of the model, and the contributions of the time window input module and the feature encoding module are more prominent, which also verifies the rationality of the structure design of the model in this paper from the side.

5 Discussion

Focusing on the issues of the fiscal operation efficiency of local institutions and the coordinated development of regional economy, this paper constructs a data-driven fiscal operation efficiency measurement model, and on this basis introduces the coupling coordination analysis and trend prediction method. From the empirical results, the efficiency of fiscal operation is not only determined by the scale of fiscal input, but also depends on whether there is a smooth transformation chain between fund allocation, budget implementation, asset utilization and public service output. When public institutions can form more stable and effective public service supply with lower resource consumption, their fiscal operation efficiency will not only be reflected in the improvement of their internal performance, but also continue to support the regional economy through channels such as education security, medical supply, cultural services and improvement of social governance

capacity. This shows that the financial operation efficiency of local institutions has the dual characteristics of public service attribute and regional development attribute in essence, and its advantages and disadvantages cannot be judged only by financial balance or expenditure scale.

In terms of regional differences, the overall level of coupling and coordination in the eastern region is relatively high, the central and western regions are in the stage of accelerating improvement, and the Northeast and some resource-based regions are relatively weak. This is closely related to the economic foundation, industrial structure, population agglomeration capacity and public resource organization mode of each region. Regions with higher levels of economic development tend to have stronger financial carrying capacity, more mature institutional environment and higher public service demand intensity, so the financial resources of public institutions are easier to transform into service performance and further feed back to regional economic growth. Relatively, in regions with insufficient economic growth momentum or greater pressure on industrial transformation, even if fiscal expenditure remains at a certain scale, the synergy effect may be limited due to inefficient use of funds, mismatched service supply structure or low asset utilization rate. Thus, fiscal operation efficiency and regional economic development is not a simple synchronous relationship, but an interactive relationship with conditional constraints and structural characteristics.

The model has achieved good results in the accuracy, convergence and robustness tests, which shows that it is necessary to introduce the data-driven method into the study of fiscal operation efficiency. Compared with traditional weighting or static evaluation methods, the data-driven model can better identify the nonlinear relationship between multi-dimensional financial indicators, and avoid the problem that the weight of a single indicator is too subjective. At the same time, the time window input and adaptive weight learning show strong contributions in the ablation experiment, indicating that the fiscal operation efficiency is not a static section concept, but has the characteristics of accumulation, stage and dynamic adjustment. Especially in the study of regional coordination, if the time dimension and external linkage are ignored and only the single-period data are used for judgment, it is often difficult to accurately describe the continuous impact of fiscal efficiency on regional economy.

From the perspective of practice, the key to improving the financial operation efficiency of local institutions is not to blindly increase financial input, but to optimize the allocation direction and use mode of financial resources. On the one hand, the precision of budget implementation and the goal orientation of project expenditure should be enhanced to reduce capital precipitation and structural inefficient occupation. On the other hand, the connection between asset management and public service output should be strengthened, and the conversion efficiency between financial funds, facilities and equipment and service supply should be improved. For regions with a low level of coordination, more attention should be paid to the overall linkage between the improvement of fiscal efficiency and the development of regional industries, the service needs of the population and the modernization of public governance, so as to avoid the separation of fiscal operation and regional economic development.

Of course, there are some limitations in this paper. Although the sample calculation well reflects the collaborative differences of different regions, it still does not fully cover the finer scale differences of counties, industry categories and internal structure differences of institutions. The construction of regional economic development index is also difficult to fully capture more complex factors such as institutional environment, population mobility and innovation network. Subsequent studies can further expand the explanatory framework of

fiscal operation efficiency and regional coordinated development on the basis of longer time span, finer spatial units and richer data sources, and strengthen the analysis of spatial spillover effects, policy shock effects and type heterogeneity, so as to improve the applicability and practical explanatory power of research conclusions.

6 Conclusion

In this paper, the financial operation efficiency of local institutions and the coordinated development of regional economy are incorporated into a unified analysis framework, and a data-driven measurement model for multi-dimensional financial indicators is constructed. On this basis, a coupling coordination analysis and trend prediction method is formed. The research shows that the efficiency of fiscal operation depends not only on the scale of fiscal input, but also on the transformation quality between fund allocation, budget implementation, asset utilization and public service output. The empirical results show that the proposed model has good performance in terms of measurement Accuracy and stability, the accuracy reaches 91.8%, the F1-score reaches 90.9%, and the training loss is reduced from 0.616 to 0.057. In terms of regional coordination, the eastern region was at a high level, and the coupling coordination degree of the Yangtze River Delta, the Pearl River Delta and the Beijing-Tianjin-Hebei region were all over 0.94, while the Harbor-Changjiang region and the northern resource-based region were 0.693 and 0.663, respectively, which still had obvious room for improvement. Ablation experiments further prove that the time window input and feature encoding module contribute most prominently. In general, the improvement of the fiscal operation efficiency of local institutions has a strong correlation with the improvement of regional resource allocation capacity, the optimization of public service supply and the improvement of economic coordination, which can provide some support for the high-quality development of the region. In the future, it is still necessary to continue to deepen the research on the basis of finer scale samples and longer time series data.

References

[1] Afonso A, Jalles J T, Venâncio A. Structural Tax Reforms and Public Spending Efficiency[J]. Open Economies Review, 2021, 32(5): 1017-1061. DOI:10.1007/s11079-021-09644-4.

[2] Afonso A, Jalles J T, Venâncio A. Taxation and Public Spending Efficiency: An International Comparison[J]. Comparative Economic Studies, 2021, 63(3): 356-383. DOI:10.1057/s41294-021-00147-2.

[3] Martínez Y U, Arzoz P P, Arregui I Z. Tax collection efficiency in OECD countries improves via decentralization, simplification, digitalization and education[J]. Journal of Policy Modeling, 2022, 44(2): 298-318. DOI:10.1016/j.jpolmod.2022.03.003.

[4] Liu G, Song J, Zhang C. Fiscal transfers and economic convergence: Evidence from China[J]. The World Economy, 2022, 45(9): 2924-2949. DOI:10.1111/twec.13260.

[5] Jia J, Ning J, Zhang J. Information transparency, monitoring, and incentives under decentralization: Evidence from China's fiscal reform of "province managing county"[J]. Journal of Regional Science, 2023, 63(2): 263-289. DOI:10.1111/jors.12615.

[6] Hou S, He J, Song L. Fiscal science and technology expenditure and the spatial convergence of regional innovation efficiency: Evidence from China's province-level data[J]. Economic Research-Ekonomska Istraživanja, 2023, 36(1): 1848-1866. DOI:10.1080/1331677X.2022.2094436.

[7] Ong K, Matthews K, Wang B. Growth versus equity: The effects of centralized fiscal transfers on Chinese provinces[J]. Regional Studies, 2023, 57(11): 2307-2322. DOI:10.1080/00343404.2022.2160868.

[8] Zhao R, He P. Government spending efficiency, fiscal decentralization and regional innovation capability: Evidence from China[J]. Economic Analysis and Policy, 2024, 84: 693-706. DOI:10.1016/j.eap.2024.08.033.

[9] Zhuo C, Luo K, Song Y, Dai L, Liu Y. Regional coordinated development and green transformation: Evidence from major national strategic zones[J]. Economic Analysis and Policy, 2024, 81: 1290-1307. DOI:10.1016/j.eap.2024.02.019.

[10] Li S, Li G. Fiscal decentralization, government self-interest and fiscal expenditure structure bias[J]. Economic Analysis and Policy, 2024, 81: 1133-1147. DOI:10.1016/j.eap.2024.01.014.

[11] Chen Y, Lyu B, Ma G. Revenue sharing, fiscal incentives, and economic growth: Evidence from China[J]. Kyklos, 2024, 77(1): 149-183. DOI:10.1111/kykl.12362.

[12] Zhang L. Public expenditure, risk sharing and economic growth[J]. The Manchester School, 2024, 92(1): 67-89. DOI:10.1111/manc.12456.

[13] Trabelsi N, Boujelbene Y. Public Sector Efficiency and Economic Growth in Developing Countries[J]. Journal of the Knowledge Economy, 2024, 15(1): 596-615. DOI:10.1007/s13132-022-01038-2.

[14] Afonso A, Fraga G B. Government spending efficiency in Latin America[J]. Empirica, 2024, 51(1): 127-160. DOI:10.1007/s10663-023-09599-4.

[15] Afonso A, Jalles J T, Venâncio A. A tale of government spending efficiency and trust in the state[J]. Public Choice, 2024, 200(1-2): 89-118. DOI:10.1007/s11127-024-01144-6.

[16] Apeti A E, Bambe B W W, Lompo A A B. Determinants of public sector efficiency: A panel database from a stochastic frontier analysis[J]. Oxford Economic Papers, 2024, 76(3): 741-758. DOI:10.1093/oep/gpad036.

[17] Bucci V, Ferrara G, Resce G. Local government spending efficiency and fiscal decentralization: Evidence from Italian municipalities[J]. Applied Economics, 2024, 56(5): 599-614. DOI:10.1080/00036846.2023.2169241.

[18] Feng P, Yasar M, Rejesus R M. Innovation and regional economic convergence: Evidence from China[J]. The Annals of Regional Science, 2024, 72(2): 535-559. DOI:10.1007/s00168-023-01210-9.

[19] Ong K, Matthews K, Wang B. The Rising Tides That Lift the Boats: Growth through Heterogeneous Convergence in Chinese Provinces[J]. Open Economies Review, 2024,

35(4): 751-778. DOI:10.1007/s11079-024-09755-8.

[20] Sugiyarto A, Lee B L, Wilson C. Narrowing the gap: Dynamics of Indonesia's public expenditure performance in economically lagging districts[J]. Economic Analysis and Policy, 2025, 85: 2299-2318. DOI:10.1016/j.eap.2025.03.014.

[21] Apeti A E, Bambe B W W, Combes J L. On the macroeconomic effects of fiscal reforms: Fiscal rules and public expenditure efficiency[J]. Public Choice, 2025, 205(1-2): 19-47. DOI:10.1007/s11127-025-01275-4.

[22] Finocchiaro Castro M, Guccio C, Romeo D, Vidoli F. How does institutional quality affect the efficiency of local government? An assessment of Italian municipalities[J]. Economia Politica, 2025, 42(2): 569-597. DOI:10.1007/s40888-025-00359-0.

[23] Mehr-un-Nisa, Qamar-un-Nisa, Khalil S. Impact of Fiscal Decentralization in Improving Public Services Delivery across Developed and Developing Districts of Punjab, Pakistan[J]. Journal of the Knowledge Economy, 2025, 16(2): 9338-9364. DOI:10.1007/s13132-024-02056-y.

[24] Liu F, Khan Y, Zhi L. Assessing the effects of regional coordinated development and ecological on public welfare in the Yangtze River Delta[J]. Environment, Development and Sustainability, 2025, 27(2): 5039-5069. DOI:10.1007/s10668-023-04376-6.

[25] Musviyanti, Khairin F N, Bone H, Syakura M A, Yudaruddin R. Structure of local government budgets and local fiscal autonomy: Evidence from Indonesia[J]. Public and Municipal Finance, 2022, 11(1): 79-89. DOI:10.21511/pmf.11(1).2022.07.