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Toward a Dynamic-Balance View of Efficiency in Regional Pension Pooling: Conceptualization, Indicator Design, and an Illustrative Case from Yingkou, China

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Abstract

This article develops a dynamic-balance view of efficiency for the analysis of regional pension pooling and uses the Yingkou case to illustrate its analytical value. Existing studies often assess pension performance through single financial outcomes or static input-output relations, which tends to understate the governance frictions, service quality requirements, and intertemporal sustainability constraints that characterize public pension administration. Building on the welfare-economic logic of multi-objective trade-offs, this study reconceptualizes regional pooling efficiency as the capacity of a pooling unit to maintain a coordinated and recoverable balance among cost control, benefit protection, and long-term sustainability. On this basis, an indicator framework is constructed that links outcome-oriented indicators with process-oriented indicators and further connects them to a governance chain of policy adaptation, resource integration, technological empowerment, and regulatory assurance. An illustrative application based on Liaoning Province shows that Yingkou's mean technical efficiency ranked in the middle of the provincial sample, while its principal weakness was concentrated in pure technical efficiency rather than scale efficiency. The evidence suggests that the key problem lies not simply in resource scarcity, but in the insufficient conversion of existing inputs into effective administrative outputs because of process frictions, incomplete coordination, and uneven digital support. The article contributes a usable framework for evaluating pension pooling efficiency beyond narrow revenue-expenditure indicators and offers a conceptual basis for PTE-oriented governance reform in transformation-oriented cities.

Keywords

Pension Insurance; Regional Pooling Efficiency; Dynamic-balance View of Efficiency; Indicator Framework; Pure Technical Efficiency; Digital Governance.

1. Introduction

As China's pension insurance reform moves from expanding coverage and raising pooling levels to improving governance quality, the question of efficiency has become increasingly central. Yet efficiency in a public pension system cannot be reduced to larger balances, lower expenditure, or faster handling time alone. Pension governance must simultaneously protect rights and benefits, ensure service accessibility, and preserve long-term sustainability under demographic ageing, economic restructuring, labor mobility, and tightening fiscal constraints. A city-level pooling unit therefore faces a multi-objective task rather than a single optimization problem.

This article argues that the regional pooling efficiency of pension insurance should be understood through a dynamic-balance view. In this view, efficiency is the capacity of a regional pooling unit to manage the tensions among cost control, benefit protection, and sustainability while remaining operationally recoverable when confronted with policy windows, technological change, and external shocks. The value of this perspective lies in shifting attention away from single-result judgments toward a more integrated observation of outcomes, processes, and governance conditions.[1-3]

The article proceeds in five steps. First, it discusses why static or single-outcome understandings of efficiency are insufficient for pension pooling analysis. Second, it develops the conceptual content of the dynamic-balance view of efficiency. Third, it proposes an indicator framework linking normative objectives to measurable outcome- and process-oriented indicators. Fourth, it uses data from Liaoning Province and Yingkou City to illustrate how the framework helps interpret efficiency decomposition results. Finally, it discusses the theoretical and policy implications of a PTE-centered reform path.[4]

2. From Single-Outcome Efficiency to Dynamic-Balance Efficiency

2.1. Why Conventional Efficiency Concepts are Insufficient

Traditional efficiency analysis usually follows one of several paths. A static efficiency perspective focuses on minimizing cost or maximizing output in the current period; a dynamic efficiency perspective emphasizes intertemporal allocation; welfare-equilibrium approaches stress fairness-efficiency trade-offs; and multi-objective pension frameworks, such as those associated with Barr and Diamond, highlight the need to reconcile adequacy, sustainability, incentives, and administrative feasibility. Each of these approaches offers important insight, but none directly translates into an operational framework for observing city-level pension pooling governance.[5-6]

Table 1. Comparison of Efficiency Perspectives in Regional Pension Pooling Analysis

Perspective / Concept	Core evaluation criterion	Primary focus	Main limitation for pooling-efficiency research
Static efficiency	Cost minimization or output maximization under a given objective	Current input-output matching	Often overlooks benefit protection and intertemporal sustainability
Dynamic efficiency	Optimality of intertemporal resource allocation	Long-term allocation and intergenerational effects	Difficult to translate directly into city-level governance variables
Welfare equilibrium	Social-welfare maximization or Pareto improvement	Fairness-efficiency trade-offs	Requires strong assumptions and has limited administrative observability
Multi-objective trade-offs	Acceptable combination among adequacy, sustainability, fairness, incentives, and feasibility	Policy conflicts among pension objectives	Needs further mapping into measurable process and governance indicators
Dynamic-balance view of efficiency	Coordinated and recoverable balancing among cost, protection, and sustainability	Institutional structure, governance capacity, and policy-tool combinations	Depends on a clear indicator system and mechanism derivation

The main limitation is that public pension administration contains dense process chains. Collection, transfer and continuation, eligibility certification, benefit calculation, payment, and

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post-event supervision are all rule-intensive and highly coordinated activities. An efficiency judgment based only on fund balance or on a narrow financial ratio risks misclassifying governance outcomes. For instance, a city may appear efficient if it reduces administrative costs or delays certain expenditures, yet such gains may be offset by weaker service accessibility, repeated verification, higher complaint rates, or the accumulation of downstream risk. Likewise, single-year balance conditions may conceal the fact that institutional resilience is weakening under policy or demographic shocks.[7-9]

For this reason, pension pooling efficiency should be observed not simply as a current revenue-expenditure result but as a governance equilibrium. What matters is whether a region can convert given institutional, fiscal, and administrative resources into stable protection outcomes through smooth processes and controllable risk. This is precisely the analytical gap that the dynamic-balance view seeks to fill.

2.2. The Dynamic-balance View of Efficiency

The dynamic-balance view of efficiency proposed in this study is not a rejection of traditional theory. Rather, it translates the welfare-economic proposition of efficiency-fairness trade-offs into a governance-oriented framework suited to regional pension pooling. Its core claim is that efficiency should be judged by whether a pooling unit can maintain a relative and repairable balance among three objectives: cost control, benefit protection, and long-term sustainability. Cost control refers not only to financial expenditure but also to the reduction of institutional friction costs such as repeated verification, repeated materials, fragmented procedures, and coordination delays. Benefit protection refers to coverage quality, timeliness and accuracy of payment, and service accessibility. Sustainability refers to the resilience of the fund-operation and governance system under shocks, demographic pressure, and policy adjustment.

This perspective carries two analytical implications. First, efficiency evaluation must jointly observe outcomes and processes. Outcome indicators reveal whether a region delivers acceptable protection and maintains fund stability, while process indicators reveal whether the governance chain operates with sufficient smoothness, consistency, and controllability. Second, efficiency improvement must be recoverable rather than merely short-lived. If a region improves speed only by compressing verification or shifting risks downstream, such gains are inconsistent with the dynamic-balance view because they weaken the long-term reliability of the system.

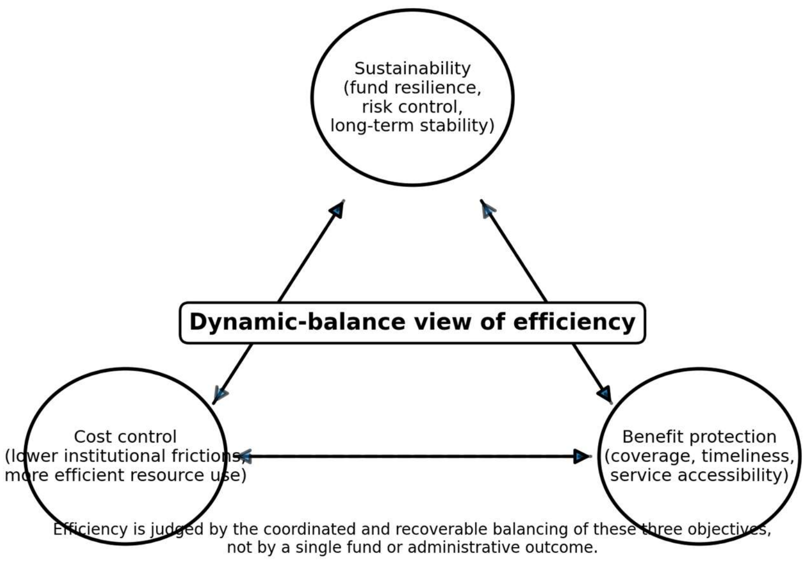

Figure 1. The dynamic-balance view of efficiency for regional pension pooling

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As shown in Figure 1, the analytical unit of efficiency is the balance itself. A region is not considered efficient merely because one node performs well. High cost compression without adequate protection, or stable payment today without sustainable risk management tomorrow, would both represent one-sided outcomes rather than genuine efficiency. The real question is whether governance arrangements can keep these objectives in coordinated motion under real-world constraints.[10]

3. Indicator Framework and Measurement Logic

3.1. From Normative Objectives to Observable Indicators

A useful pension-efficiency framework must connect normative goals to observable evidence. Based on the dynamic-balance view, the present article distinguishes between outcome-oriented indicators and process-oriented indicators. Outcome-oriented indicators show what the system delivers; process-oriented indicators show how those outcomes are produced. This distinction is essential because city-level efficiency gaps often stem not from absolute shortages of resources but from weak conversion efficiency between inputs and outputs.

Outcome-oriented indicators in this framework include the fund collection rate, fund payment capacity, and participation coverage rate. These respectively reflect the quality of revenue realization, the sustainability of payment capacity, and the protection reach of the system. Process-oriented indicators include the average processing time for transfer and continuation, the share of services handled online, and the accuracy rate of intelligent audit warnings. These indicators reveal whether digitalization, administrative coordination, and regulatory assurance are actually embedded in the operation chain rather than merely existing as formal inputs.

Importantly, the indicator framework also needs a bridge to governance action. In this study, that bridge is provided by a four-dimensional governance chain composed of policy adaptation, resource integration, technological empowerment, and regulatory assurance. The function of these four levers is not identical: policy adaptation defines implementation boundaries and rule consistency; resource integration improves the deployment of fiscal, organizational, and human resources; technological empowerment reduces friction and improves processing efficiency; and regulatory assurance preserves system credibility and risk control.[11]

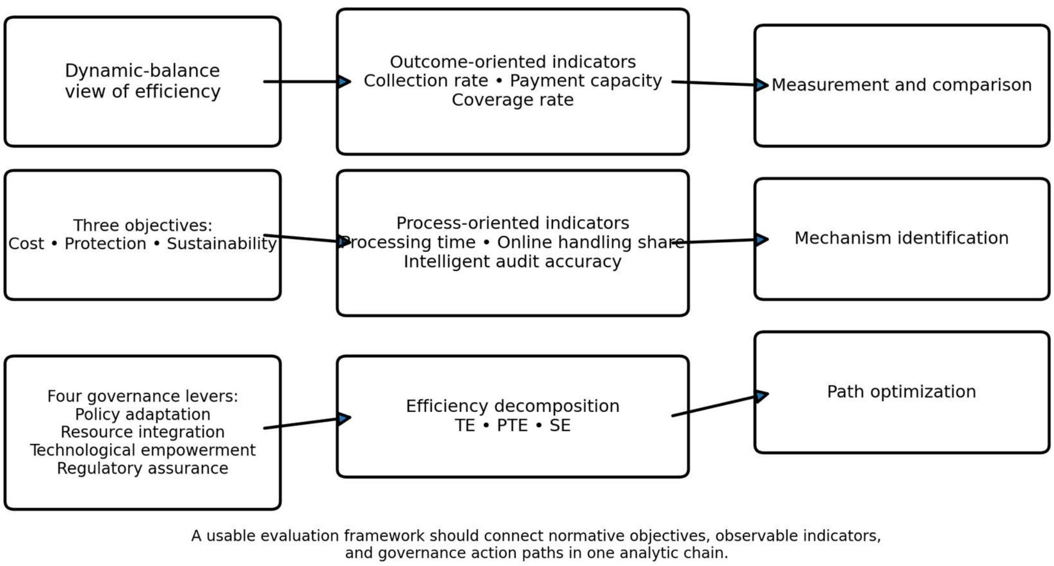

Figure 2. Linking the dynamic-balance view, indicators, and governance action paths

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Table 2. Core Indicator Framework for Measuring Regional Pension Pooling Efficiency

Indicator dimension	Core indicator	Analytical meaning	Illustrative data source
Outcome-oriented indicators	Fund collection rate (actual contributions / due contributions)	Quality of contribution realization and effective fund inflow	Annual reports of social security administration
Outcome-oriented indicators	Fund payment capacity (accumulated balance / average monthly expenditure)	Short- to medium-term sustainability and payment resilience	Human resources and social security statistical yearbooks
Outcome-oriented indicators	Participation coverage rate (actual participants / eligible participants)	Breadth and quality of protection	Local human-resources-and-social-security departments
Process-oriented indicators	Average processing time for transfer and continuation	Administrative efficiency and procedural smoothness	Social security business system logs
Process-oriented indicators	Share of services handled online	Depth of digital service substitution and accessibility	Digital platform operation statistics
Process-oriented indicators	Accuracy rate of intelligent audit warnings	Risk-regulation capacity and quality of digital supervision	Fund supervision and intelligent-audit systems

3.2. Why Efficiency Decomposition Matters

The dynamic-balance view also requires that efficiency be decomposed. In the dissertation from which this article is derived, an SBM-DEA framework under variable returns to scale is used to separate overall technical efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE). This distinction matters because the governance meaning of low PTE differs from that of low SE. Low PTE typically points to process frictions, coordination failure, weak digital support, uneven standards, or incomplete risk-control loops. Low SE, by contrast, is more closely related to mismatches between resource scale and the size of the pooling unit. In policy terms, mistaking a PTE problem for an SE problem can lead to ineffective prescriptions, such as expanding inputs when the real bottleneck is process conversion.[12]

The indicator framework is therefore designed not only for descriptive observation but also for mechanism identification. Once efficiency is decomposed, the analyst can ask whether a city's weak outcomes stem from governance-process shortcomings or from broader structural and scale constraints. This allows governance recommendations to be more targeted and sequential.

4. Illustrative Application: Yingkou in the Liaoning Provincial Sample

4.1. Provincial Comparison

To illustrate the framework, this section uses the provincial sample reported in the dissertation, which covers 13 prefecture-level cities in Liaoning Province from 2015 to 2024. Figure 3 presents the mean TE values of these cities. Yingkou's mean TE was 0.66, placing it in the middle of the sample. This position suggests that Yingkou is neither a frontier city nor an extreme laggard. Such a middle position is analytically useful because it reduces the risk of treating either extraordinary advantages or extreme weakness as representative.

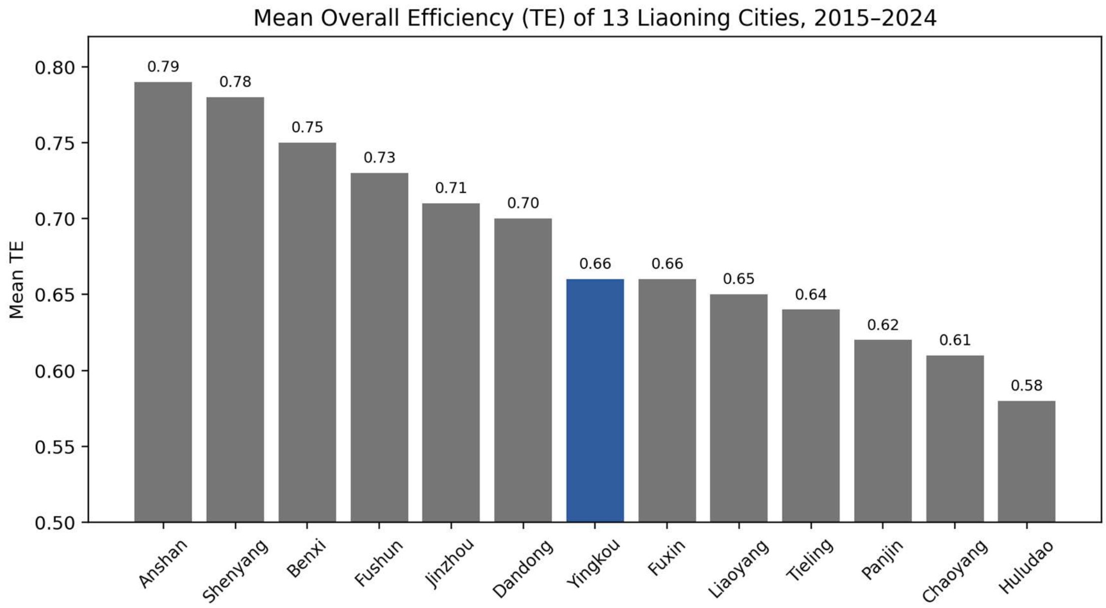

Figure 3. Mean overall efficiency (TE) of 13 cities in Liaoning Province, 2015–2024

More importantly, the provincial comparison should not be read as a simple ranking exercise. Under the dynamic-balance view, a city's place in the provincial distribution only establishes relative position. The more substantive question is how that position is produced. Is the gap mainly due to insufficient process efficiency, or does it primarily reflect a scale mismatch under structural constraints? The answer requires decomposition.

4.2. Annual Decomposition And Interpretation

Figure 4 reports Yingkou's annual TE, PTE, and SE from 2015 to 2024. Across the whole period, PTE remained consistently lower than SE. In 2020, TE fell to 0.61 and PTE to 0.54, whereas SE remained at 0.88. By 2024, TE rose to 0.72 and PTE to 0.66, but SE still stayed much higher at 0.90. This pattern indicates that Yingkou's efficiency weakness was concentrated mainly in process efficiency rather than in scale efficiency.

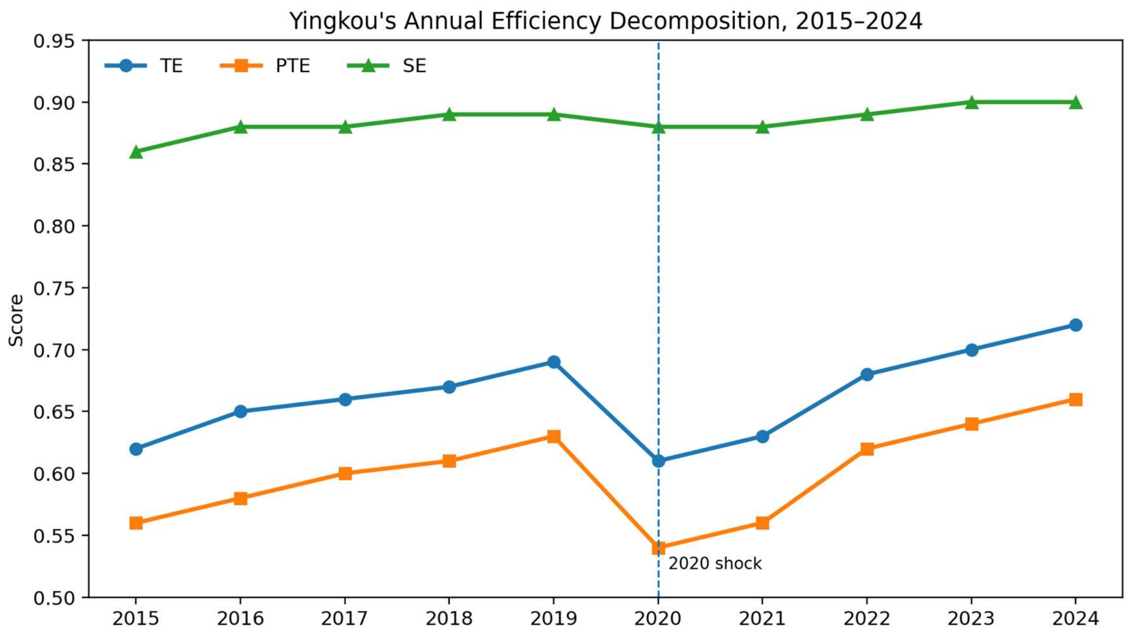

Figure 4. Annual efficiency decomposition of Yingkou City, 2015–2024

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The interpretation of these results is straightforward but important. If a city's SE is already relatively close to the frontier, broad recommendations to enlarge resource inputs, expand administrative scale, or rely mainly on additional fiscal support are unlikely to address the main problem. A PTE-centered diagnosis instead points to administrative and procedural bottlenecks: repeated verification, inconsistent standards, insufficient online substitution, delayed transfer-and-continuation processing, weak automatic verification, and incomplete integration between front-end service and back-end supervision.

This is precisely where the dynamic-balance framework adds value. A single TE score might tell us that Yingkou is below the provincial frontier, but decomposition shows why. At the same time, the indicator framework clarifies what evidence should be examined next. If the collection rate, payment capacity, and coverage rate do not deteriorate sharply while process indicators remain weak, the likely conclusion is that the city is not suffering primarily from an absolute shortage of resources; instead, it faces conversion losses in the governance chain. From a reform perspective, this is a more actionable diagnosis.

Table 3. Illustrative Evidence on Yingkou's Relative Position and Decomposition

Indicator	Value	Interpretation	Governance implication
Mean TE of Yingkou (2015–2024)	0.66	Middle position in the provincial sample	Benchmarking should focus on internal structure rather than only rank
Mean rank in sample	7th of 13 cities	Neither frontier nor extreme laggard	Useful as a representative transformation-oriented case
PTE in 2020	0.54	Sharp process-efficiency decline during the shock year	Policy windows and coordination capacity matter
SE in 2020	0.88	Scale efficiency remained relatively stable	Scale was not the primary short-run bottleneck
PTE in 2024	0.66	Recovered but still below SE	Process optimization still required
SE in 2024	0.90	Near-frontier scale performance	Reform priority should remain PTE-oriented

5. Discussion

5.1. Theoretical Implications

The first theoretical implication of the article is that pension pooling efficiency should be framed as a governance problem rather than as a narrowly financial one. This does not deny the importance of fund balance or payment pressure; instead, it places them within a larger structure where service quality, administrative feasibility, digital capacity, and regulatory assurance also matter. The dynamic-balance view therefore expands the evaluative meaning of efficiency and aligns it more closely with the real tasks of public pension administration.

The second implication is methodological. Because the concept of efficiency is broadened, the measurement system must also broaden. Outcome indicators alone are insufficient, but process indicators without an outcome anchor are also incomplete. The proposed framework combines both and then adds a governance-action bridge. In this sense, the framework is not only descriptive but diagnostic: it helps identify where bottlenecks lie and which reform lever is most relevant.

5.2. Policy Implications

The policy implication for transformation-oriented cities such as Yingkou is that efficiency improvement should begin with the strongest leverage points affecting PTE. Such measures include closed-loop digital handling of high-frequency business, simplification and standardization of eligibility-certification procedures, expansion of automatic cross-department verification, unification of data standards, and the embedding of supervision in the administrative process. These actions reduce institutional frictions without requiring immediate large-scale expansion of the pooling unit.

At the same time, the dynamic-balance view also warns against superficial digitalization. Platform construction by itself does not guarantee efficiency improvement. If online systems merely duplicate offline procedures, or if data are connected but standards remain inconsistent, technological investment can become a new source of friction rather than a solution. Therefore, digital governance must be evaluated through process performance indicators such as online-substitution rate, one-stop completion rate, reprocessing rate, and warning accuracy, not only through project counts or system coverage.

Finally, efficiency gains should be judged for sustainability. Short-term speed improvements that undermine verification quality, increase downstream remediation, or weaken institutional trust cannot be treated as genuine efficiency. The policy goal is thus not one-off acceleration but a stable governance chain that is easier to coordinate, easier to monitor, and more resilient under shocks.

6. Conclusion

This article has proposed a dynamic-balance view of efficiency for the analysis of regional pension pooling and has illustrated its usefulness through the Yingkou case. The framework reconceptualizes efficiency as the coordinated and recoverable balancing of cost control, benefit protection, and sustainability. It further translates this view into an indicator system that combines outcome-oriented and process-oriented indicators and connects them to a four-dimensional governance chain of policy adaptation, resource integration, technological empowerment, and regulatory assurance.

The illustrative evidence shows that Yingkou's main weakness lies in pure technical efficiency rather than in scale efficiency, indicating that process conversion and coordination bottlenecks matter more than simple resource scarcity. This supports a PTE-centered reform logic in which digital governance, standardization, interdepartmental coordination, and embedded supervision are treated as primary levers of improvement.

More broadly, the article suggests that regional pension pooling research can move beyond narrow revenue-expenditure evaluation toward a more complete framework that is conceptually coherent, empirically observable, and policy-usable. For future research, the next step is to test this framework on broader cross-regional samples and to incorporate finer-grained administrative process data so that the transmission path from governance tools to efficiency outcomes can be identified with even greater precision.

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