

Regional Pooling Efficiency of Pension Insurance Under Unified Provincial Pooling: Evidence from Yingkou City, Liaoning Province

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Abstract

Drawing on the dissertation research on China's pension insurance governance, this paper examines the regional pooling efficiency of pension insurance in Yingkou City under the background of unified provincial pooling rules. Using prefecture-level cities in Liaoning Province as comparable samples for 2015–2024, the study constructs an input-output-constraint indicator system and applies the Slack-Based Measure Data Envelopment Analysis model under variable returns to scale to estimate overall efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE). It further employs a panel Tobit model to identify the key factors associated with efficiency differences. The results show that Yingkou belongs to the provincial middle tier, with a mean TE of 0.66, slightly below the provincial mean of 0.68. Its major bottleneck lies in PTE rather than SE: Yingkou's mean PTE is 0.60, whereas its mean SE reaches 0.89, indicating that the city's room for improvement is concentrated mainly on the process-governance side rather than in further scale expansion. The annual series shows a trajectory of gradual improvement, short-term decline in 2020, and recovery after 2021, again confirming the dominant role of process efficiency in shaping overall efficiency. The regression results further indicate that institutional closure, economic conditions, digital governance, and institutional-technological synergy are positively associated with efficiency, whereas demographic pressure and fiscal stress impose significant constraints. On this basis, the paper proposes a process-oriented optimization path centered on policy adaptation, resource integration, technological enablement, and regulatory assurance. The study provides both an analytical framework and practical evidence for improving pension insurance governance in transformation-oriented cities.

Keywords

Pension insurance; regional pooling efficiency; Yingkou City; SBM-DEA; panel Tobit; digital governance.

1. Introduction

1.1. Research Background and Significance

With the continued advancement of China's national and provincial pooling reforms in basic pension insurance, the main source of regional differences in institutional performance is shifting from differences in institutional design to differences in implementation quality. Under a unified rule framework, local governments still differ markedly in industrial structure, fiscal capacity, demographic pressure, governance foundations, and digital capability. As a result, the same institutional rules may generate significantly different outcomes across cities. In this sense, the municipal pooling unit remains a key level for observing the real quality of pension insurance governance.

Traditional discussions often equate pension insurance efficiency with static fund balances or the simple compression of administrative expenditure. However, such an interpretation is too

narrow for a public security institution whose objectives include cost control, benefit protection, and long-term sustainability at the same time. The present study follows the dynamic-balance view of efficiency advanced in the dissertation and defines regional pooling efficiency as the comprehensive governance performance through which a pooling unit, under unified institutional rules, achieves a relative coordination among administrative cost, protection outcomes, and long-run resilience. This perspective makes it possible to distinguish structural constraints from governable space and to avoid misjudging low levels of protection as efficiency gains.

1.2. Research Status at Home and Abroad

Existing studies on pension insurance have generally evolved from three main directions. The first concerns reform of the pooling level, fund adjustment, and institutional equity. This line of research emphasizes that a higher pooling level can enlarge the scope of risk sharing and reduce fragmentation. The second focuses on efficiency measurement, mainly through DEA-type methods and related comparative frameworks, in order to identify interregional gaps in public-service and social-insurance performance. The third turns toward governance effectiveness, highlighting the role of digitalization, process reengineering, and cross-department coordination in shaping actual implementation quality.

Although these studies have generated valuable findings, at least three limitations remain. First, many studies stop at measurement and do not sufficiently explain why efficiency differs or where the main bottlenecks lie. Second, governance and process variables such as digital governance, information sharing, and administrative coordination are often treated as background conditions rather than as core explanatory dimensions. Third, research grounded in specific municipal contexts remains comparatively limited. These shortcomings make it difficult to transform abstract efficiency scores into operational reform priorities. The Yingkou case therefore offers a useful opportunity to connect efficiency measurement, mechanism explanation, and policy design within one coherent analytical chain.

1.3. Research Content and Methods

This paper focuses on the period 2015–2024 and uses the 13 prefecture-level cities of Liaoning Province as comparable objects. The research proceeds in three steps. First, it measures the relative efficiency of regional pension pooling through an SBM-DEA model under variable returns to scale and decomposes TE into PTE and SE. Second, it identifies the main factors associated with efficiency variation by means of a panel Tobit model. Third, based on the empirical evidence, it interprets a process-oriented optimization path for Yingkou centered on institutional adaptation, resource integration, technological enablement, and regulatory assurance.

The empirical strategy is designed to answer two questions simultaneously: where Yingkou stands within the provincial efficiency structure, and why its room for improvement is concentrated mainly in process efficiency rather than on the scale side. In this way, the study moves beyond descriptive comparison and seeks to provide a more policy-relevant interpretation of efficiency.

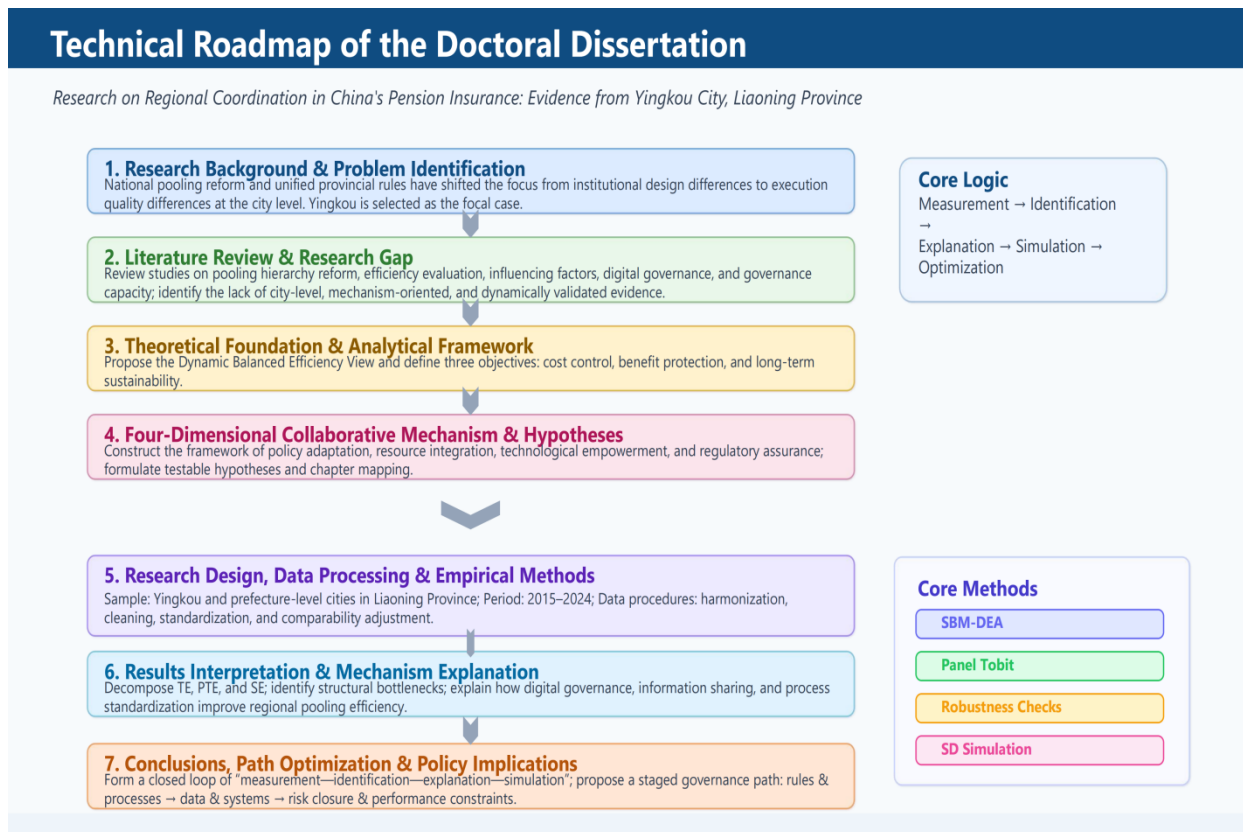


Figure 1 Technical Roadmap

2. Theoretical Basis of Regional Pooling Efficiency in Pension Insurance

2.1. The Dynamic-Balance View of Efficiency

The dynamic-balance view regards pension insurance efficiency as a multidimensional performance rather than a one-dimensional financial result. Its central concern is whether the system can, within institutional boundaries, maintain a workable balance among three objectives: lower institutional friction costs, adequate benefit protection, and sustainable long-run operation. This understanding is especially important in old industrial-base cities, where population ageing, employment transformation, and fiscal pressure often interact. Under such conditions, efficiency cannot be judged merely by current balances or by the compression of expenditures.

From a measurement perspective, this view justifies the use of a decomposition framework. TE reflects the overall level of relative efficiency, PTE captures the quality of process organization and governance transformation, and SE reflects the degree of matching between scale and resource allocation. Once efficiency is decomposed in this way, the practical meaning of reform becomes clearer: a city with relatively high SE but low PTE does not primarily need additional scale expansion, but rather improved process coordination, better data connectivity, and more consistent institutional implementation.

Table 1 Classification of Research Paradigms and Methods for Pension Pooling Efficiency Studies

Research Paradigm	Core Methods	Application Scenarios	Representative Studies
Institutional and Policy Analysis	Normative analysis; policy text	Logic of pooling-level reform; allocation of	He Wenjong et al. (2022), study on the design of the national pooling system

	interpretation	central-local responsibilities	
Efficiency Measurement and Comparison	DEA; SBM-DEA; Malmquist index	Regional efficiency ranking; input-output optimization	Zeng Yi et al. (2025), comparison of provincial pooling efficiency
Policy-effect Identification	DID; synthetic control; event study	Evaluation of central adjustment and tax-based collection policies	Lu Jinfei et al. (2023), test of the incentive effects of the adjustment system
Data-governance Measurement	Process-data mining; mediation-effect models	Transmission mechanisms through which digital governance affects efficiency	Lu Wei et al. (2023), study on information sharing and collection efficiency

2.2. Governance Capacity, Digitalization, and Process Efficiency

Pension insurance is a highly proceduralized and rule-dependent system. Links such as contribution declaration, transfer and continuation, eligibility certification, payment verification, audit, and risk warning depend on unified data standards and effective coordination across departments. In many cases, low efficiency is not caused by flawed rules themselves, but by friction in implementation—for example, inconsistent information standards, repeated review, insufficient interdepartmental linkage, delayed warning, and fragmented case handling.

Digital governance can mitigate these frictions through at least four channels. It can reduce transaction costs by enabling online declaration, electronic materials, and automatic verification; it can improve information consistency by promoting cross-department data sharing and standardized interfaces; it can strengthen risk regulation through big-data matching and intelligent warning; and it can support targeted expansion of insurance participation by identifying groups such as flexible workers more accurately. These process variables are therefore not merely technical supplements, but central drivers of efficiency improvement.

2.3. Analytical Framework

Combining the efficiency-decomposition logic with the governance perspective, this paper adopts an analytical framework in which institutional conditions, economic foundations, demographic pressure, fiscal stress, and digital governance jointly shape regional pooling efficiency. Among these factors, institutional closure and digital capability are especially important because their interaction affects whether local governments can convert formal rules into real process capacity. The empirical expectation is that if Yingkou’s main problem lies on the PTE side, then the city’s reform priorities should focus on standardization, data connectivity, service integration, and closed-loop supervision rather than on purely increasing inputs.

3. Empirical Research and Effect Analysis

3.1. Intercity Comparison in Liaoning Province

The first empirical step is to locate Yingkou within the provincial distribution of pension pooling efficiency. The results show a relatively clear gradient structure among the 13 cities of Liaoning Province. Frontier cities such as Anshan and Shenyang remain close to the efficiency frontier, whereas lower-ranked cities such as Chaoyang and Huludao lag more substantially. Yingkou's mean TE is 0.66, which places it in the middle tier of the province. This means that Yingkou is neither a disordered tail-end case nor a frontier city; rather, it is a typical transformation-oriented city with visible but diagnosable room for improvement.

A further decomposition reveals that Yingkou's structural problem is not symmetrical across indicators. Compared with the provincial mean and with the benchmark city Anshan, Yingkou's deficiency is concentrated mainly in PTE, while its SE remains relatively high. This finding is analytically important because it implies that Yingkou's efficiency gap is not fundamentally a scale problem. Instead, the gap arises more from the quality of process organization, data coordination, and governance transformation.

3.2. Annual Evolution of Efficiency in Yingkou City

The annual series of Yingkou's efficiency scores further confirms the dominance of process efficiency. From 2015 to 2019, Yingkou's TE rose steadily from 0.62 to 0.69, indicating gradual improvement. In 2020, TE declined to 0.61, followed by a recovery to 0.68 in 2022 and continued growth to 0.72 in 2024. Over the same period, PTE and TE moved almost in parallel, whereas SE remained comparatively stable around 0.86–0.90.

This pattern suggests that Yingkou's efficiency evolution is not a simple story of scale adjustment. Rather, it is a process-governance story: the city's overall efficiency changes mainly when process efficiency declines or recovers. The 2020 downturn and the post-2022 rebound therefore provide strong empirical evidence that the main source of variation lies on the PTE side. In practical terms, this means that future gains depend more on reducing administrative frictions and improving coordination than on pursuing further scale expansion.

3.3. Regression Results and Mechanism Interpretation

The panel Tobit regression results provide additional support for the process-oriented explanation. Institutional closure (Inst), economic foundations (Econ), digital governance (Tech), and the interaction between institutions and technology (Inst×Tech) all show positive associations with efficiency. Demographic pressure (Pop) and fiscal stress (Fiscal), by contrast, impose significant constraints. The positive coefficient of the post-2022 dummy also indicates that the reform window after 2022 is associated with an improvement in regional pooling efficiency.

Among these results, the interaction between institutions and technology is particularly revealing. Its positive and significant coefficient indicates that improved rules and stronger digital capability reinforce each other. This means that digital tools cannot independently create governance dividends if institutional standards remain unclear; likewise, institutional closure alone may not deliver efficiency gains if data connectivity and process execution remain weak. The regression evidence therefore matches the decomposition results: Yingkou's improvement depends less on changing scale and more on building a coordinated process-governance system.

Taken together, the empirical evidence shows that Yingkou's structural shortcoming can be summarized as a combination of relatively stable scale efficiency and insufficient process efficiency. This makes its reform direction more diagnosable than that of a city suffering from compound shortcomings on both sides.

4. Policy Implications and Optimization Path

4.1. Process-Oriented Governance Improvement

The first implication of the findings is that Yingkou should treat process efficiency as the principal entry point for reform. High-frequency and high-friction matters—such as transfer and continuation, benefit eligibility certification, repeated review, and cross-department verification—should be sorted first, because improvements in these links can directly compress institutional friction costs and raise PTE. In this sense, the city's main task is not to expand scale, but to improve the conversion rate from given inputs to actual governance outcomes.

This also means that generic resource-input thinking has limited explanatory power. Since Yingkou's SE is already relatively high, simply increasing expenditure or enlarging the scope of pooling cannot automatically close the efficiency gap. A more productive strategy is to standardize business rules, reduce duplicated handling, and improve the consistency of data and processes across departments.

4.2. Four-Dimensional Collaborative Mechanism

On the basis of the dissertation, the optimization path can be summarized into a four-dimensional collaborative mechanism. The first dimension is policy adaptation, through which unified national and provincial rules are translated into a workable list of local standards and exceptional-case procedures. The second is resource integration, which reorganizes personnel, budgets, data interfaces, and administrative attention around key business chains. The third is technological enablement, which turns rules and resources into replicable operating capacity through system integration, rule engines, and online handling. The fourth is regulatory assurance, which embeds supervision into the process through warning, spot checks, and traceability.

These four dimensions should not be treated as isolated measures. Policy adaptation defines the boundary of reform, resource integration provides the implementation basis, technological enablement improves actual processing capacity, and regulatory assurance stabilizes the gains through closed-loop control. Their joint operation is therefore essential for breaking Yingkou's PTE bottleneck.

4.3. Implementation Suggestions

In practical terms, the reform sequence should move from rule sorting and standard unification, to data sharing and platform linkage, and then to embedded supervision and performance constraints. The initiation stage should prioritize one-stop handling of high-frequency matters, online substitution, and automatic cross-department verification. The deepening stage should focus on transforming fragmented systems into a more connected architecture and on making exceptional-case handling more transparent and standardized. The institutionalization stage should integrate key indicators such as online completion rate, automatic verification coverage, and closed-loop warning response into regular assessment.

For transformation-oriented cities similar to Yingkou, the broader implication is that municipal pension insurance reform under unified provincial pooling is increasingly a question of governance quality rather than of rule design alone. Cities that can more effectively align institutional rules, resource organization, digital tools, and regulatory capacity are more likely to move from the middle tier toward the efficiency frontier.

5. Summary

Based on the dynamic-balance view of efficiency, this paper analyzes the regional pooling efficiency of pension insurance in Yingkou City and draws three principal conclusions. First, Yingkou belongs to the middle tier within Liaoning Province and remains slightly below the

provincial mean in overall efficiency. Second, its major shortcoming lies in pure technical efficiency rather than scale efficiency, indicating that the city's main room for improvement is concentrated on the process-governance side. Third, institutional closure, digital governance, and their synergy are crucial drivers of efficiency improvement, whereas demographic pressure and fiscal stress remain important constraints.

Therefore, the key to raising regional pooling efficiency in Yingkou is not simple scale expansion, but the construction of a process-oriented governance system based on policy adaptation, resource integration, technological enablement, and regulatory assurance. This conclusion not only deepens the explanation of pension insurance efficiency at the municipal level, but also provides a practical reference for similar cities operating under unified provincial pooling rules.

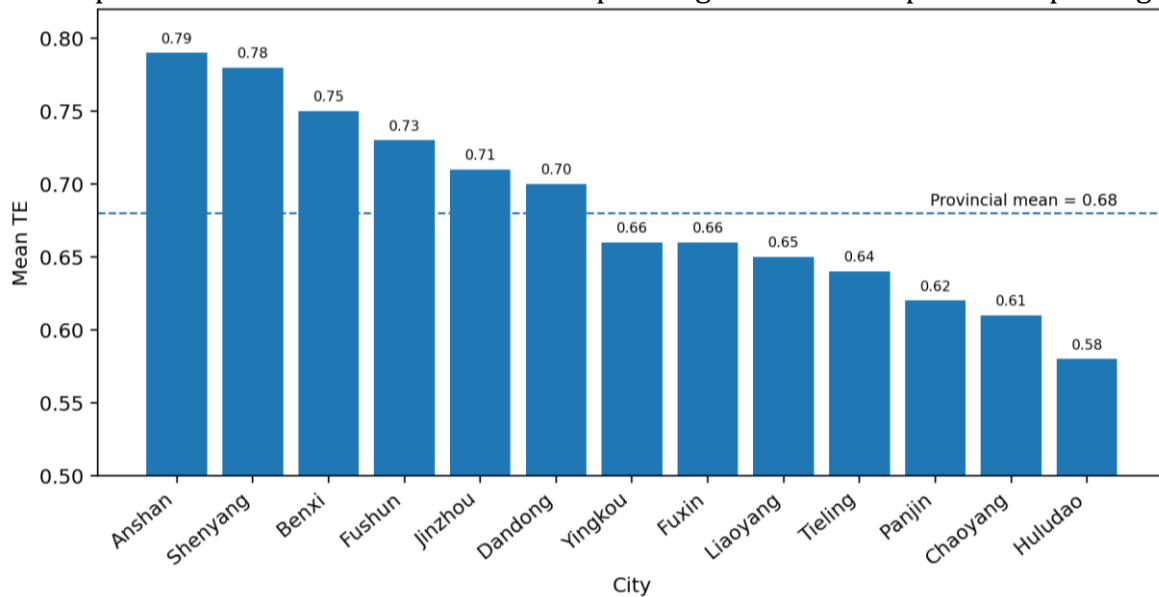


Figure 2 Mean Overall Efficiency (TE) of 13 Cities in Liaoning Province (2015–2024)

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