

Public Asset Optimization and Going-Concern Sustainability of a Regional Water Enterprise: A Springate Model Approach

Ady Setiawan^{1*} 

¹Surabaya Technology University,
Jl. Balongsari Praja V No.1, Surabaya City, East Java 60188, Indonesia
*Corresponding Email: ady.setiawan@utssurabaya.ac.id

ARTICLE INFORMATION

Publication information

Research article

HOW TO CITE

Setiawan, A. (2026). Public asset optimization and going-concern sustainability of a regional water enterprise: whether the financial-distress signal A Springate model approach. *International Journal of Accounting and Finance in Asia Pacific*, 9(3), 1197-1217.

DOI:

<https://doi.org/10.32535/ijafap.v9i3.4735>

Copyright @ 2026 owned by Author(s).
Published by IJAFAP



This is an open-access article.

License:

Attribution-Noncommercial-Share Alike
(CC BY-NC-SA)

Received: 11 August 2026

Accepted: 18 September 2026

Published: 20 October 2026

ABSTRACT

Regional government-owned enterprises (Badan Usaha Milik Daerah, BUMD) in Indonesia carry a dual mandate of public service and commercial return, leaving many municipal water utilities financially fragile while their buried distribution assets deteriorate unseen. This study examines the financial-distress signal produced by the Springate model for Perumda Air Minum Tirta Moedal, Semarang City, is corroborated by the efficiency of its public-asset use. Four discriminant ratios from audited financial statements for 2018-2024 were computed into annual S-Scores and triangulated with non-revenue water (NRW) and Infrastructure Leakage Index (ILI) evidence. The S-Score ranged from 1.0133 to 2.1347, above the 0.862 cut-off in every year, yet the activity ratio stagnated at 0.57-0.69, NRW reached 44.59% in 2024 against a 20% national target, and a critical district recorded an ILI of 16.04. This soundness therefore appears structurally insulated by monopoly tariffs and fiscal support rather than efficiency-earned, a condition termed pseudo going-concern. These findings support prioritizing capital expenditure toward water-loss reduction and provide a basis for future research on predictive early-warning analytics.

Keywords: Asset Optimization; Going-Concern Sustainability; Infrastructure Leakage Index; Non-Revenue Water; Project-Based Asset Governance; Springate Model

JEL Classification: G32; G33; H54; L95

INTRODUCTION

The going-concern assumption is a foundational principle in the preparation of financial statements, asserting an entity's ability to sustain operations over the long term. When this ability is impaired by macroeconomic pressure or internal inefficiency, the entity enters a phase of financial distress that, left without tactical intervention, can culminate in bankruptcy. Within Indonesia's regional economy, regional government-owned enterprises (Badan Usaha Milik Daerah, BUMD) occupy a role that is strategic and, simultaneously, dilemmatic (Lestari et al., 2024; Machmud et al., 2023).

National governance data illustrate the fragility of the sector. Of roughly one thousand BUMD operating in Indonesia, a substantial share still records operating losses, while their aggregate dividend contribution to regional own-source revenue (pendapatan asli daerah, PAD) remains low (Sumaryana et al., 2024). The root of this dilemma is the dual mission of BUMD as both a public-service provider and a commercial engine of regional profit: when the social function dominates, for example through tariffs set below production cost, financial performance is suppressed, whereas a purely commercial orientation risks neglecting social equity (Aprila et al., 2023; Apriono et al., 2023).

Among BUMD, regional drinking-water enterprises (Perusahaan Daerah Air Minum, PDAM) are particularly exposed to this collision of missions. National performance evaluations show that only a fraction of the utilities classified as healthy fully satisfy the standards of water quality, quantity, and continuity, while most still struggle to achieve full cost recovery (World Bank, 2025). The structural problem is compounded by chronic water loss across distribution networks.

Indonesia's water sector operates under deep fiscal decentralization: responsibility for service provision rests with local governments while financing has historically depended on central transfers. As those allocations decline, the funding gap increasingly falls on constrained regional budgets, exposing utilities to chronic under-investment in network rehabilitation (Sumaryana et al., 2024; World Bank, 2025). For an enterprise whose principal assets are buried pipelines with multi-decade service lives, deferred maintenance accumulates silently and surfaces only through rising water loss and energy costs, long after the accounting statements have reported apparently stable surpluses.

The going-concern question is therefore a public-policy concern rather than an accounting formality, because the continuity of a water utility underpins both citizens' access to a basic need and the fiscal health of the region that owns it. Financial-distress prediction models translate complex financial statements into a single, interpretable signal of failure risk, allowing supervisory boards and regional governments to intervene before distress becomes irreversible (Ambarwati et al., 2025; Setiawan & Gultom, 2025). Yet the practical value of such a signal depends on whether it is read alongside the operational drivers of value; applied mechanically, a reassuring score may foster complacency about deteriorating assets, an integration gap this study seeks to close.

Perumda Air Minum Tirta Moedal, Semarang City, is one of the largest water-service providers in Central Java, serving more than two hundred thousand active connections through an installed production capacity of 3,600 liters per second, with service coverage in the range of 52-60%. The enterprise was selected as Indonesia's representative in an international initiative aimed at achieving financial independence without reliance on regional-budget subsidies, yet its operational reliability is shadowed by the classic problem of high non-revenue water (NRW) (Wiedilaksono et al., 2024).

Water loss at the enterprise has been alarming: cumulative NRW stood at approximately 39% in 2019 and rose to 44.59% in 2024, with independent water-balance studies recording even higher figures in intervening years (Wiedilaksono et al., 2024). Physical leakage from corroded pipelines, together with apparent losses from meter inaccuracy, directly erodes potential water-sales revenue and degrades the efficiency of fixed-asset utilization, while raising production cost per cubic meter through wasted energy and chemicals.

Most bankruptcy-prediction studies in Indonesia focus on firms listed on the Indonesia Stock Exchange (Milleniasari & Yunita, 2024; Setiawan & Gultom, 2025; Wijayanto et al., 2025), whereas application to monopolistic BUMD, whose incentive and funding structures differ markedly, remains limited. Prior work also tends to stop at a healthy or distressed label without connecting that label to the physical condition of the operational assets that generate entity value. This gap motivates the present study, which integrates the Springate discriminant indicator with the dynamics of public-asset optimization, tariff-adjustment policy, and external partnership financing.

Three features distinguish this study. First, it extends Springate-based distress modeling, conventionally applied to listed firms, to a monopolistic regional water enterprise whose incentive and funding structures differ fundamentally. Second, rather than stopping at a healthy or distressed label, it couples the financial score with physical-asset and project-governance indicators, namely NRW, the Infrastructure Leakage Index (ILI), district-metered-area (DMA) losses, public-private partnership (PPP) structuring, and capital-expenditure reallocation, thereby reframing going-concern sustainability as an asset- and project-management problem rather than a purely accounting one. Third, it outlines an explainable predictive-analytics agenda as a proposal for future research. Accordingly, the study measures the going-concern sustainability of the enterprise over 2018-2024 using the Springate model and examines the alignment between that financial score and the efficiency of public-asset utilization, in support of regional fiscal sustainability.

LITERATURE REVIEW

Theoretical Framework: Grand, Middle, and Applied Theory

This study rests on a three-tier theoretical structure: a grand theory establishing the accountability premise of public-enterprise management, a middle-range theory translating it into a measurable financial-continuity construct, and an applied theory operationalizing continuity through asset-efficiency metrics. Read jointly, the three layers frame going concern as the combined product of stewardship, financial resilience, and asset optimization.

Grand Theory — Stewardship Theory

At the most abstract level, stewardship theory frames the conduct expected of the directors of a BUMD. Unlike agency theory, which assumes opportunistic managers who must be monitored and constrained, stewardship theory holds that managers are intrinsically motivated to act as trustworthy stewards of the assets entrusted to them, aligning their behavior with the collective objectives of the principal rather than with private gain (Davis et al., 1997). For a water utility owned by a city government, the principal is the regional government and the citizenry it serves, so the steward's mandate is the preservation and productive use of public assets for sustained public service rather than profit maximization (Amanda & Kesuma, 2025; Machmud et al., 2023). Within this frame, the deterioration of physical assets, for example, chronic pipe leakage that inflates non-revenue water, is interpreted as a stewardship deficit that erodes public value and threatens the long-term continuity of the enterprise.

Middle Theory — Financial Distress and Going-Concern Theory

This tier bridges governance intent and financial reality. Going concern is the foundational accounting assumption that an entity will continue operating for the foreseeable future, whereas financial distress denotes the deteriorating condition that precedes failure, marked by illiquidity, insolvency, and eroding profitability (Ambarwati et al., 2025). The empirical tradition of multivariate discriminant analysis established that accounting ratios carry an early-warning signal of failure risk, a lineage that the Springate model continues (Altman, 1968; Springate, 1978). The middle theory matters here because it converts the abstract stewardship mandate into an observable, quantifiable construct: whether the enterprise can credibly sustain operations, and whether the financial signal it emits is consistent with the operational condition that lies beneath it.

Applied Theory — Public-Asset Optimization Theory

At the operational level, public-asset-optimization theory expresses continuity in concrete technical terms as the deliberate effort to maximize the service output and economic value of separated regional assets across their life cycle (Sumaryana et al., 2024). For a drinking-water enterprise whose principal assets are buried transmission and distribution networks, the decisive efficiency metric is the rate of water loss, captured by NRW and benchmarked by the ILI within the standard international water-balance framework (Lambert & Hirner, 2000; Wiedilaksono et al., 2024). These metrics render the otherwise invisible condition of physical assets directly measurable, allowing the financial diagnosis produced at the middle level to be tested against the real efficiency of asset utilization rather than accepted at face value. The three tiers thus converge on a single proposition: genuine going-concern sustainability is demonstrated only when a sound financial signal is corroborated by the efficient stewardship of physical assets.

Stewardship Theory and BUMD Asset Management

Applied to a BUMD, the stewardship frame sharpens the accountability created by the dual mandate: leadership success is judged by how effectively directors optimize separated regional assets for public utility alongside a healthy dividend contribution, not by short-term surplus alone (Amanda & Kesuma, 2025; Davis et al., 1997). That latitude carries a latent risk: where a natural monopoly or a standing fiscal backstop blunts the financial consequences of inefficiency, the disciplining feedback stewardship presumes weakens and asset deterioration persists behind a reassuring financial surface. Pipe leakage driving high non-revenue water is therefore a stewardship deficit rather than a merely technical lapse (Lestari et al., 2024; Machmud et al., 2023).

The Springate Model (S-Score)

The Springate model was developed by Gordon L. V. Springate in 1978, following the Altman procedure, by using step-wise multiple discriminant analysis to select the four ratios best able to distinguish bankrupt from non-bankrupt firms from a set of nineteen popular financial ratios (Altman, 1968; Springate, 1978). The model is parsimonious yet powerful in capturing signs of declining liquidity, solvency, profitability, and activity, with reported initial accuracy of about 92.5% (Milleniasari & Yunita, 2024). The Springate discriminant function is expressed as:

$$S = 1.03 \cdot X1 + 3.07 \cdot X2 + 0.66 \cdot X3 + 0.40 \cdot X4$$

where X1 is working capital to total assets; X2 is earnings before interest and tax (EBIT) to total assets; X3 is earnings before tax to current liabilities; and X4 is sales to total assets. The cut-off is set at 0.862. If S exceeds 0.862, the firm is classified in the non-distress (healthy) zone; if S is at or below 0.862, the firm is in financial distress with a high risk of bankruptcy (Setiawan & Gultom, 2025; Wijayanto et al., 2025). In this study,

the S-Score is used as a financial-distress signal to inform the assessment of going-concern sustainability.

Public-Asset Optimization and Non-Revenue Water

For a PDAM, distribution assets such as pipes, reservoirs, and meters are the principal revenue generators, so the water-loss rate becomes the core indicator of asset efficiency. NRW comprises physical (real) losses from network leakage and commercial (apparent) losses from meter inaccuracy and illegal consumption. National policy sets a maximum NRW of 20%, with the ILI as the technical benchmark of infrastructure leakage (Nanda et al., 2024; Naradipta & Slamet, 2024). Framing these assets within a life-cycle asset-management system aligns the enterprise with the asset-management capability adopted by other Indonesian state-owned utilities (Pharmatrisanti et al., 2023), under which non-revenue water serves as the decisive efficiency benchmark (Goh & See, 2023).

Public-Private Partnership and Infrastructure Financing

Closing the investment gap in water infrastructure increasingly relies on PPP schemes, known in Indonesia as Kerja Sama Pemerintah dengan Badan Usaha (KPBU). Under such arrangements, a private partner finances and builds bulk-water infrastructure and recovers its investment through a long-term off-take agreement, while the enterprise retains distribution and customer-facing functions. From a financial-structuring standpoint, PPP keeps large construction liabilities off the enterprise's balance sheet, preserving solvency ratios and protecting working capital from lumpy capital expenditure (Schoeman & Chakwizira, 2023; Wiedilaksono et al., 2024). The trade-off is a fixed long-term payment obligation and a heightened need for tariffs that support full cost recovery. Treating each PPP as a governed project, with explicit risk allocation, performance milestones, and revenue assurance, connects the financial-distress lens to project-management discipline, and this bridge is what distinguishes the present study from prior work that analyzes the discriminant score in isolation.

Empirical Evidence on Bankruptcy-Prediction Models

Comparative studies of discriminant-based prediction models in Indonesia report mixed but instructive findings. Across retail, manufacturing, energy, and property samples, the Springate model frequently classifies firms as healthy, at times more optimistically than the Zmijewski or Grover models, because its heavy weight on the profitability-to-asset term rewards positive operating surpluses (Milleniasari & Yunita, 2024; Muzani & Yuliana, 2021; Robiansyah et al., 2022). Property-sector evidence finds it less accurate than leverage-oriented models under volatile conditions, underscoring that no single model dominates and that context and recalibration matter (Setiawan & Gultom, 2025). Evidence that pairs data envelopment analysis with discriminant models further indicates that explicit efficiency measurement adds diagnostic information beyond ratio-based scores alone (Amelia & Setiawan, 2022). For a monopolistic utility insulated from competition, a healthy score should therefore be read cautiously and triangulated with operational evidence rather than as conclusive proof of sustainability.

Subsequent BUMD-level evidence repeatedly shows the operational counterpart to such scores. Nanda et al. (2024) report that Perumda Air Minum Palangka Raya operated at 51.84% non-revenue water, implying a foregone revenue of about IDR 15.4 billion per year, while Naradipta and Slamet (2024) document a 31.67% loss rate at Perumda Delta Tirta Sidoarjo that nonetheless yields an Infrastructure Leakage Index of 69.35 and an annual revenue loss of roughly IDR 132.7 billion. The same pattern recurs: a sound book-level signal paired with a deteriorating physical network, mirroring the structural paradox examined here.

Research Propositions Development

Building on the literature, this study treats the Springate score as an indicator of financial sustainability and the NRW level as an indicator of operational sustainability (asset efficiency). A discrepancy is plausible: the financial score may appear healthy while real-asset efficiency is low, especially in a monopolistic entity that can offset inefficiency through tariffs charged to a captive customer base and through regional fiscal support. Comparative Indonesian studies confirm that the Springate model frequently classifies utilities and incumbents as healthy even amid operational weakness (Muzani & Yuliana, 2021; Robiansyah et al., 2022). Two research propositions are therefore formulated and evaluated through classification rules, pattern comparison, and triangulation of the financial and operational evidence.

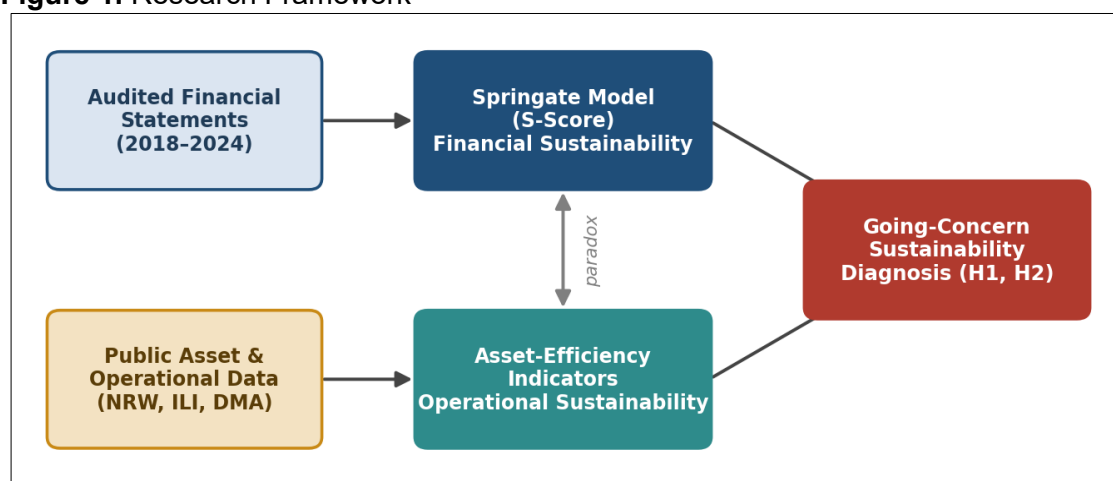
P1: The Springate S-Score of Perumda Air Minum Tirta Moedal lies consistently within the non-distress (healthy) zone throughout 2018-2024.

P2: The financial soundness implied by the Springate score does not fully reflect asset-utilization efficiency, as evidenced by stagnant activity ratios and persistently high non-revenue water.

Conceptual Framework

The study framework is depicted in Figure 1. The Springate score (financial sustainability) and the asset-efficiency indicators (operational sustainability) are evaluated jointly to diagnose going-concern sustainability and to test the proposed paradox between solvency and asset efficiency.

Figure 1. Research Framework



RESEARCH METHOD

Research Approach and Design

This study adopts a quantitative, descriptive-analytical approach within a post-positivist research paradigm. Two a priori propositions (P1 and P2) are specified in advance and evaluated against empirical evidence through decision-rule classification and methodological triangulation. The quantitative element is the processing of numerical financial ratios; the descriptive-analytical element interprets the going-concern condition that those ratios reveal across the observation period.

The design is a single-entity longitudinal case study spanning 2018-2024, a window that brackets the COVID-19 shock and allows the score to be read across pre-pandemic, pandemic, and post-pandemic sub-periods within one consistently governed entity. The study therefore claims no statistical generalization; its external validity rests on analytic

generalization of the observed mechanism, the divergence between financial solvency and physical-asset efficiency under a regulated monopoly, to theory and to structurally comparable BUMD (Yin, 2018). The Springate model, ex ante by construction, is here applied ex post to realized audited statements as a diagnostic instrument.

Paradigm Grounding and Design Rationale

Two design principles follow directly from this grounding and govern the analysis. First, the study is an explanatory single-case design in which the case is selected as a critical test of an existing theoretical proposition rather than as a representative sample (Yin, 2018). Second, the propositions are assessed by pattern comparison: the pattern predicted by an efficiency-earned reading of the score is tested against the observed record of asset performance, and the retained explanation is the one consistent with both evidence streams. The Springate coefficients are treated as a fixed diagnostic instrument rather than re-estimated weights, so the object of testing remains the established model.

Data Sources and Selection

The data are secondary. The core financial inputs are the audited Statements of Financial Position and Profit or Loss of Perumda Air Minum Tirta Moedal for 2018-2024, audited by an independent public accounting firm and reviewed by the regional Finance and Development Supervisory Agency (BPKP). Supporting evidence on NRW, DMA conditions, partnership schemes, and tariff regulation was drawn from official company publications, a peer-reviewed water-balance study of the same enterprise, and regional regulations (Pemerintah Kota Semarang, 2025; Perumda Air Minum Tirta Moedal Kota Semarang, 2025a, 2026; Wiedilaksono et al., 2024). Selection was purposive: seven consecutive years of audited statements containing every line item required to compute the four Springate ratios. Table 1 summarizes each source, its observation period, the indicators obtained, and its role in the analysis.

Table 1. Data Sources, Observation Period, and Role in the Analysis

Data Source	Observation Period	Data or Indicators Obtained	Role in the Analysis
Audited financial statements (statements of financial position and profit or loss)	2018-2024	Total assets, current assets, current liabilities, working capital, earnings before tax, operating revenue	Computation of X1-X4 and the annual S-Score (Tables 2-4)
Internal DMA distribution-planning document (Plamongan Indah)	2024	Input volume, billed volume, physical and commercial losses, ILI, financial loss	District-level asset-efficiency diagnostic (Table 6)
Peer-reviewed water-balance study of the same enterprise	2019-2024	NRW rate and leakage benchmarks	Independent cross-check of the operational evidence (Table 5)
Company profile and Regional Work Plan and Budget (RKA)	2025-2026	Installed capacity, service coverage, planned capital injection	Contextual scaling assumptions (Table 7) and discussion of prospective policy
Regional tariff regulation	2025	Tariff structure and adjustment authority	Interpretation of tariff policy and cost recovery

Note: Only the audited financial statements enter the discriminant computation.

Two distinct categories of company documents are used, and the boundary is made explicit to prevent conflation. The audited financial statements for 2018-2024 are statutory, externally validated reports and the sole source of every figure entering the discriminant computation. The 2025 Regional Work Plan and Budget (rencana kerja dan anggaran, RKA) is a forward-looking, unaudited planning instrument that enters none of

those computations and is cited only as context for prospective capital injection and tariff adjustment.

Operational Definition of Variables

The variables are the four ratios that constitute the Springate score. X1 (working capital to total assets) measures net liquidity available for daily operations relative to scale. X2 (earnings to total assets) relates operating profit to total assets and reflects asset productivity. X3 (earnings before tax to current liabilities) evaluates current solvency using the year's operating surplus. X4 (revenue to total assets) measures asset-turnover effectiveness in converting fixed-asset capacity into revenue.

Because the audited statements do not present EBIT separately, earnings before tax (EBT) serve as the EBIT proxy in X2, a common practice in Indonesian PDAM studies. Two considerations support this substitution and bound its effect. First, the enterprise carries little interest-bearing debt, because its largest transmission investment is financed through a partnership structure that keeps the construction liability off its balance sheet, so the arithmetic gap between EBIT and EBT is small. Second, the substitution is conservative by construction: interest expense cannot be negative, so EBIT is greater than or equal to EBT, and using EBT therefore understates X2 and X3 and understates the resulting S-Score. Restoring interest expense could only raise the score, and cannot move a year already classified above the cut-off into the distress zone, so the annual classifications reported below are unaffected by the proxy.

Beyond the discriminant ratios, the study uses NRW as its principal asset-efficiency indicator, operationalized on the standard international water-balance basis as the difference between system input volume and billed authorized consumption, expressed as a percentage of system input volume; it aggregates real (physical) losses, apparent (commercial) losses, and unbilled authorized consumption (Lambert & Hirner, 2000). District-level losses are benchmarked through the ILI (Wiedilaksono et al., 2024). Because the percentage indicator is sensitive to consumption and pressure and can understate technical inefficiency, the ILI is treated as the more reliable measure of physical-asset condition, consistent with efficiency assessments that incorporate NRW as an undesirable output (Goh & See, 2023).

Data Analysis Method

The analysis proceeded as follows. Key line items were compiled from the audited statements; X1 to X4 were computed for each year and aggregated through the discriminant function into the annual S-Score; the result was classified against the 0.862 cut-off; and the scores were then linked to the asset-efficiency indicators (NRW, ILI, and DMA financial loss) to assess consistency between financial soundness and operational efficiency. All computations were performed in spreadsheet software.

To strengthen validity, the financial findings were triangulated against independent operational evidence, including a peer-reviewed water-balance study of the same enterprise and official regulatory benchmarks (Wiedilaksono et al., 2024). This mitigates the single-method risk of a discriminant-only analysis and allows the study to assess whether financial soundness is grounded in efficient asset use. Reliability rests on statements verified by an independent accountant and reviewed by the regional BPKP, and the transparent computation permits replication.

Because the Springate function was estimated on Canadian listed firms in the 1970s, its coefficients are applied as a fixed diagnostic instrument rather than locally recalibrated weights. The analysis therefore emphasizes the trajectory and component decomposition of the score alongside the activity ratio, NRW, and ILI evidence.

Comparing these financial and operational indicators year by year allows divergence between accounting soundness and asset efficiency to be identified explicitly.

RESULTS

Description of Financial Data

Table 2. Historical Financial Data of Perumda Air Minum Tirta Moedal, 2018-2024 (IDR billion)

Item / Year	2018	2019	2020	2021	2022	2023	2024
Total assets	364.23	395.80	448.29	515.69	557.60	585.66	621.70
Current assets	117.99	135.52	195.36	261.59	237.11	207.73	171.71
Current liabilities	33.48	47.57	33.77	38.80	37.60	41.80	38.70
Net working capital	84.52	87.94	161.58	222.79	199.51	165.93	133.01
Earnings before tax	18.99	46.60	56.96	60.14	63.76	64.85	66.30
Operating revenue	218.39	271.37	291.50	310.12	319.02	351.16	386.96

Source: Audited financial statements of Perumda Air Minum Tirta Moedal (processed, 2026).

Table 2 compiles the key financial line items underlying the Springate computation. Over 2018-2024, total assets grew from IDR 364.23 billion to IDR 621.70 billion (compound annual growth rate, CAGR, of 9.32%), earnings before tax rose from IDR 18.99 billion to IDR 66.30 billion (CAGR of 23.17%), and operating revenue increased from IDR 218.39 billion to IDR 386.96 billion (CAGR of 10.00%), indicating consistent expansion of the capacity and revenue base.

Discriminant Ratios

Table 3. Springate Discriminant Ratios (X1-X4), 2018-2024

Item / Year	2018	2019	2020	2021	2022	2023	2024
X1 = Working capital / total assets	0.2320	0.2222	0.3604	0.4320	0.3578	0.2833	0.2139
X2 = EBT / total assets	0.0521	0.1177	0.1271	0.1166	0.1144	0.1107	0.1066
X3 = EBT / current liabilities	0.5673	0.9796	1.6867	1.5498	1.6957	1.5511	1.7134
X4 = Revenue / total assets	0.5996	0.6856	0.6503	0.6014	0.5721	0.5996	0.6224

Note: EBT is used as the EBIT proxy in X2.

Table 3 presents the four raw ratios. The liquidity ratio (X1) fluctuated between 0.2139 and 0.4320, reflecting positive and strong working capital. The profitability ratio (X2) rose sharply from 0.0521 in 2018 to the 0.11–0.13 band from 2019 onward, then eased gently. The solvency ratio (X3) jumped from 0.5673 to above 1.5 from 2020, signaling an operating surplus far exceeding current liabilities. By contrast, the efficiency ratio (X4) remained relatively stagnant within 0.5721–0.6856, an early signal of constrained asset utilization.

Read together, the ratios reveal a clear structural signature. Liquidity and solvency are strong and broadly improving; profitability stabilized at a healthy level after 2019, but activity remained inert. In a capital-intensive utility, a flat sales-to-assets ratio in the face of steadily growing total assets indicates that newly added capacity did not translate proportionally into billed water sales. This divergence between an expanding asset base and a stagnant turnover ratio is the earliest quantitative trace of the inefficiency that the operational data later confirm, and it is invisible to a reader who consults only the headline profit or the aggregate score.

Springate Score and Health Classification

Table 4. Weighted Contributions, Springate Score, and Classification, 2018-2024

Item / Year	2018	2019	2020	2021	2022	2023	2024
1.03 · X1 (Liquidity)	0.2390	0.2289	0.3713	0.4450	0.3685	0.2918	0.2204
3.07 · X2 (Profitability)	0.1601	0.3615	0.3901	0.3580	0.3511	0.3399	0.3274
0.66 · X3 (Solvency)	0.3744	0.6465	1.1132	1.0229	1.1192	1.0238	1.1308
0.40 · X4 (Efficiency)	0.2398	0.2743	0.2601	0.2405	0.2288	0.2398	0.2490
Springate score (S)	1.0133	1.5111	2.1347	2.0664	2.0676	1.8953	1.9276
Classification	Healthy	Healthy	Healthy	Healthy	Healthy	Healthy	Healthy

Note: Cut-off = 0.862.

Table 4 reports the weighted contribution of each ratio, the final S-Score, and the resulting classification. The S-Score ranged from 1.0133 in 2018 to 2.1347 in 2020, averaging 1.8023, and consistently exceeded the 0.862 cut-off. Throughout 2018-2024, therefore, the Springate signal placed Perumda Air Minum Tirta Moedal in the non-distress zone, supporting P1.

Table 5. Reported Non-Revenue Water and Infrastructure Leakage Index, 2018-2024

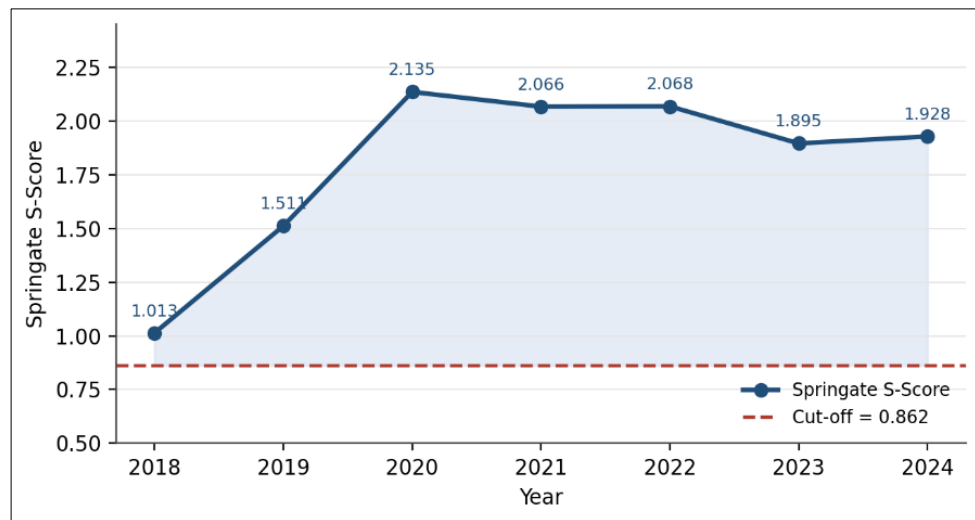
Year	NRW (%)	ILI	Evidence source
2018	Not available	Not available	No published figure
2019	≈ 39.00	Not available	Wiedilaksono et al. (2024)
2020	Not available	Not available	No published figure
2021	Not available	Not available	No published figure
2022	Not available	Not available	No published figure
2023	Not available	Not available	No published figure
2024	44.59	16.04 (DMA level)	Company report; internal DMA study

Note: A complete audited annual series is not published; years without an independently verifiable figure are shown as not available. The 2024 ILI is measured at district level.

Table 5 assembles the operational counterpart to the financial series. A complete audited annual series of NRW and ILI is not published for the enterprise, so the comparison rests on the years for which independently verifiable evidence exists: the loss rate stood at approximately 39% in 2019 and 44.59% in 2024, and the ILI is evidenced at district level for 2024. Two features are nonetheless clear. The loss rate did not decline across the window, and in the most recent year it remained more than twice the 20% national target. Read against **Table 4**, the operational record therefore moves in the opposite direction to the financial score, which is the divergence that P2 anticipates.

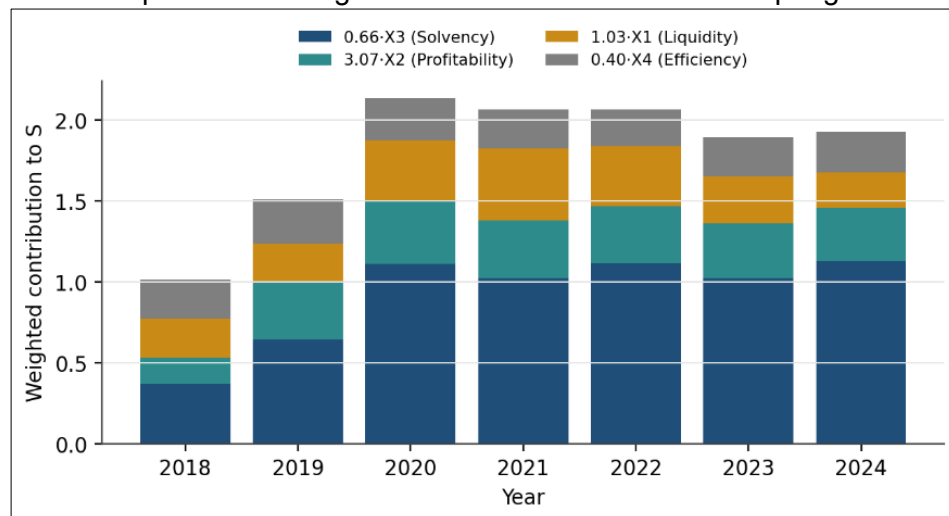
The trend of the Springate score relative to the cut-off is shown in **Figure 2**. A sharp post-pandemic increase in 2020-2022 consolidated in 2023-2024, yet every value remained well above the cut-off line.

Figure 2. Springate Score Trend Against the Cut-off, 2018-2024



Decomposing each ratio's contribution to the score (Figure 3) shows that the principal support of the score is the solvency component ($0.66 \cdot X_3$), which has contributed more than half of S since 2020. By contrast, the efficiency component ($0.40 \cdot X_4$) is nearly flat at 0.23-0.27 across the seven years. This pattern becomes the point of departure for the paradox discussed below.

Figure 3. Decomposition of Weighted Ratio Contributions to the Springate Score



District-Metered-Area Micro-Analysis

To illustrate the operational reality behind the financial score, Table 6 reports a water-loss analysis for a critical service cluster, the Plamongan Indah DMA in the East Semarang service area, for 2024.

Table 6. Physical Leakage, Commercial Loss, and Financial Impact at the Plamongan Indah DMA (2024)

Indicator	Actual value	Benchmark / Reference	Operational implication
Distributed water input volume	580,416 m ³ /yr	None	Total supply into the local pipe network
Water sold and billed	304,566 m ³ /yr	None	Volume recorded at meters (cash-generating)
NRW level	47.53% (275,850 m ³)	< 20.00% (regulatory target)	Extreme +27.53% deviation from the safe threshold
Physical (real) losses	43.19% (250,693 m ³)	No regulatory target	Driven by main-pipe damage and reservoir overflow
Commercial (apparent) losses	4.33% (25,157 m ³)	No regulatory target	Aged inaccurate meters and illegal consumption
Direct financial loss	IDR 1,603,791,900/yr	No benchmark	Cash potentially lost in a single DMA cluster
Infrastructure Leakage Index (ILI)	16.04	1.00-4.00 (technical band, best)	Category D (very severe infrastructure leakage)

Note: The 20% benchmark applies to total NRW, while the ILI range represents a technical performance classification. No separate regulatory benchmark is available for physical losses, commercial losses, or financial loss.

Source: Enterprise DMA water-balance study; benchmarked against [Wiedilaksono et al. \(2024\)](#).

Table 6 shows quantitatively that the inefficiency of an aging distribution network generates a direct financial loss of roughly IDR 1.6 billion per year in a single DMA, with an ILI of 16.04, which falls in Band D, the worst category of the international technical leakage classification for developing countries (ILI above 16). This is revenue that evaporates before it can ever be recorded in the income statement, so that a healthy Springate score conceals significant lost value.

Two points qualify this micro-analysis. First, the DMA figures derive from an internal 2024 distribution-planning document supplied under a confidentiality arrangement; it is treated as one triangulated evidence stream and cross-checked against the independent water-balance study of the same enterprise ([Wiedilaksono et al., 2024](#)). Second, although the dataset is not public, the procedure is replicable: applying the standard water-balance and ILI definitions to any utility's input and billed-volume records reproduces the figures, and the pattern matches comparable Indonesian districts ([Nanda et al., 2024](#); [Naradipta & Slamet, 2024](#)).

Table 7. Illustrative Scenario Estimate of City-Wide Non-Revenue Water Value, 2024

Parameter	Estimate	Basis
Installed production capacity	3,600 L/s	Company profile
Estimated annual system input volume	≈ 95,000,000 m ³	Capacity × assumed average utilization
NRW rate (2024)	44.59%	Reported
Estimated annual NRW volume	≈ 42,360,000 m ³	System input volume × NRW rate
Unit value of lost water	IDR 5,814 / m ³	Derived from Plamongan Indah DMA
Gross potential value of NRW	≈ IDR 246 billion / yr	NRW volume × unit value

Share of 2024 operating revenue	≈ 64%	vs IDR 386.96 billion
Conservatively recoverable (one-third)	≈ IDR 82 billion / yr	Illustrative lower bound
Sensitivity range of gross value	≈ IDR 218-280 billion / yr	Input volume 84-108 M m ³ (74-95% utilisation)

Note: Illustrative scenario estimate derived from company operating data and the Plamongan Indah DMA unit value. It is an order-of-magnitude extrapolation under the stated utilization assumptions, not an audited total.

Across this utilization band, the gross potential value stays between roughly IDR 218 billion and IDR 280 billion per year, so the order-of-magnitude conclusion is insensitive to the input assumption.

The city-wide magnitude can be approximated from the enterprise's operating scale (Table 7). At an installed capacity of 3,600 liters per second and an assumed average utilization, annual system input is of the order of 95 million cubic meters. Hence, the 2024 NRW rate of 44.59% implies roughly 42 million cubic meters lost each year. Valued at IDR 5,814 per cubic meter, the gross potential value is on the order of IDR 246 billion per year, about three-fifths of 2024 operating revenue, of which perhaps one-third may be realistically recoverable. The estimate illustrates how losses in a single cluster can scale into a material financial exposure (Goh & See, 2023; Kingdom et al., 2006).

DISCUSSION

The Springate Diagnosis and Financial Sustainability (P1)

The consistent classification of the firm in the non-distress zone supports P1 and aligns with comparative Indonesian evidence that the Springate model tends to place incumbent and capacity-expanding firms in the safe zone (Milleniasari & Yunita, 2024; Setiawan & Gultom, 2025; Wijayanto et al., 2025). The post-pandemic surge in the score is explained primarily by the solvency component, as the operating surplus rapidly outgrew modest current liabilities. In a single-period accounting sense, the ratios reported in Tables 3 and 4 show an entity that is solvent and carries no signal of short-term failure.

The Solvency-Asset-Efficiency Paradox (P2)

Maintaining the Springate score far above the safe threshold produces a paradox once set against operational reality, which supports P2. Within this case, the apparent financial health may be influenced by the natural-monopoly structure of urban water provision and continuing fiscal support from the Semarang City government. In a monopolistic market, cost inefficiency arising from asset deterioration can be offset by tariffs charged to captive customers, so that the reported surplus need not reflect operating efficiency (Apriono et al., 2023; Machmud et al., 2023). The stagnation of the activity ratio (X4) within 0.57-0.69 reported in Table 3 is consistent with this reading: each rupiah of invested asset has not generated proportional sales volume, and the NRW and ILI evidence in Tables 5 and 6 indicates that a substantial share of output is lost before reaching customer meters.

The implication is methodological as well as managerial. A discriminant model calibrated on competitive, listed firms may transfer imperfectly to a regulated monopoly, where pricing power and a fiscal backstop can sustain solvency even when operational efficiency is weak. Analysts applying such models to BUMD should pair the score with sector-specific efficiency benchmarks such as NRW and the ILI; otherwise, the reassurance may delay the corrective investment continuity requires (Machmud et al., 2023; Sumaryana et al., 2024).

Read through the stewardship lens, the paradox carries a governance hazard. Stewardship presumes that directors, granted discretion rather than tight monitoring, will internalize the principal's objectives and preserve the assets entrusted to them (Amanda & Kesuma, 2025; Davis et al., 1997). That presumption depends on a feedback loop in which inefficiency is financially visible and consequential. In a natural monopoly buffered by tariff power and capital injection, that loop appears muted in this case, so a reassuringly high score may foster a false sense of security in which the metric meant to discipline management instead insulates it from the consequences of asset neglect.

The same logic helps explain why the distress signal remains reassuring despite pronounced operating weakness. In the competitive samples for which discriminant models were calibrated (Altman, 1968; Springate, 1978), a 44.59% NRW rate would translate directly into lost sales and a slide toward insolvency. In this case, the enterprise appears shielded: as the sole provider, it can recover the cost of inefficiency through tariffs on captive customers, while capital shortfalls have been absorbed by regional capital participation. The financial-distress signal is therefore real but, on the present evidence, partly exogenous, as summarized in Table 8.

Table 8. Taxonomy of the Qualified Paradox

Concept	Definition	Diagnostic evidence in this case
Structurally insulated rather than efficiency-earned	Financial health generated by monopoly pricing power and a standing fiscal backstop, not by productive asset use.	Healthy S-Score carried by solvency (X3); captive tariffs; regional capital injection.
Pseudo going-concern	Continuity that holds only while the monopoly position and fiscal support persist, not on the strength of asset productivity alone.	NRW 44.59% (2024); stagnant activity ratio X4 of 0.57-0.69; ILI in the worst international band.
Qualified paradox	A financial signal that is genuinely sound yet only partially informative, reconciled once its common structural source is understood.	Divergent branch of the diagnostic (Figure 4): a sound score coincident with inefficient assets.

Public-Asset Optimization and Non-Revenue Water

The most critical physical inefficiency is reflected in NRW reaching 44.59% in 2024, far above the 20% national target and above the national average (Kingdom et al., 2006; Naradipta & Slamet, 2024). The DMA-level evidence in Table 6 shows that physical losses dominate at 43.19% against 4.33% of commercial losses, indicating that the priority is rehabilitation of distribution infrastructure rather than commercial-loss control alone. From a stewardship perspective, this water loss is not merely a technical metric but a manifestation of an asset-management deficit that may erode long-term going-concern sustainability (Amanda & Kesuma, 2025; Davis et al., 1997; Sumaryana et al., 2024).

Quantifying the stakes clarifies the urgency. One cluster forfeits roughly IDR 1.6 billion per year, and the city-wide estimate indicates an aggregate loss an order of magnitude larger, so redirecting capital toward physical-loss reduction appears more consequential than capacity expansion that pushes more water into a leaking network (Sumaryana et al., 2024).

Public-asset-optimization theory also explains why X4 stayed inert at 0.57-0.69 despite a growing asset base: the ratio measures how effectively fixed-asset capacity converts into billed revenue, so its stagnation is the financial fingerprint of a network that expands faster than it is made watertight. Capacity additions, including the West Semarang KPBU investment, enlarge total assets, yet their contribution to billed sales is constrained where distributed water escapes before reaching meters (Goh & See, 2023; Wiedilaksono et al., 2024). Until leakage falls, further investment raises assets without proportionally raising turnover.

The Economic Asymmetry between Loss Reduction and Capacity Expansion

The paradox carries a direct capital-budgeting interpretation. Every cubic meter abstracted, treated, pressurized, and then lost to leakage carries the full marginal cost of production without offsetting revenue, so physical loss is doubly destructive: it forfeits the tariff the water would have earned and sinks the variable cost already spent. At a 44.59% NRW rate, close to half of the energy and chemical budget is spent on water that never reaches a billable meter, inflating the unit cost of every cubic meter actually sold.

The marginal returns on the two paths are therefore asymmetric. In a leaking network, added capacity also adds the cost of the additional losses and depresses the activity ratio, whereas reducing leakage recovers saleable volume and lowers unit cost at once. On the evidence of this case, staged leakage reduction appears to offer a higher return on scarce capital than capacity expansion, so a preference for visible new infrastructure over pipe rehabilitation is a misallocation the headline score does nothing to discourage (Sumaryana et al., 2024).

Public-Private Partnership Financing and Balance-Sheet Protection

Facing limited regional capital expenditure for large-scale transmission, the enterprise employed a PPP on the West Semarang system. From a bankruptcy-risk perspective it works through three mechanisms: it mitigates direct debt burden, because the private party finances the treatment plant, intake, pipes, and reservoirs, keeping hundreds of billions of rupiah of long-term debt off the balance sheet and sustaining the solvency ratio (X3) above 1.0 from 2020; it allocates operational risk by transferring raw-water availability and quality risk to the implementing entity; and it enhances supply reliability, since round-the-clock supply to critical western districts eases tariff adjustment (Kingdom et al., 2006; Wiedilaksono et al., 2024). In project-management terms, the PPP is a risk-transfer and capital-structuring instrument that shields the score even as physical-asset challenges persist.

The same instrument, however, carries a governance caveat. A long-term off-take obligation converts a flexible capital decision into a fixed periodic commitment, so the protection it confers is contingent on the enterprise's ability to monetize the additional bulk water through reliable distribution and disciplined tariff collection. Where distribution losses remain severe, water purchased under a take-or-pay structure can itself become non-revenue water, transforming a balance-sheet advantage into a recurring operating drain (Schoeman & Chakwizira, 2023).

Capital Injection, Stewardship, and Asset Optimization

To accelerate coverage, the Semarang City government periodically provides regional capital injection (penyertaan modal daerah, PMD), including a non-PPP allocation planned for 2025 (Perumda Air Minum Tirta Moedal Kota Semarang, 2025b). However, evidence on regional water enterprises indicates that capital injection does not automatically advance targets such as safe-water access; it becomes significantly positive only when mediated by improved internal operational efficiency (Machmud et

al., 2023; Pharmatrisanti et al., 2023). If PMD funds are absorbed by operating inefficiency or merely add capacity without improving network quality, the public investment risks being wasted as leaked water. Asset-management policy therefore needs a shift from supply-side expansion toward demand-side conservation of existing distribution assets.

This reorientation has a measurable financial logic. Because the activity ratio responds to billed volume, every percentage point of recovered water lifts X4, reduces the unit cost embedded in X2, and strengthens the cash position underpinning X1 and X3, so one intervention reinforces all four components of the score. A stewardship-oriented board would therefore treat loss reduction as the central value-preservation strategy and embed leakage and ILI targets in the dashboard that monitors solvency and profitability (Davis et al., 1997; Sumaryana et al., 2024).

Tariff Policy, Social Equity, and the Full-Cost-Recovery Trade-off

The dual mandate surfaces most concretely in tariff policy, where full cost recovery collides with affordable access. A monopolistic utility can restore profitability simply by raising tariffs for captive customers, and prevailing mayoral regulation provides the legal instrument (Pemerintah Kota Semarang, 2025). However, a tariff increase without a corresponding reduction in non-revenue water would shift part of the cost of operational inefficiency to households, including payments for water that does not reach customers. From a stewardship standpoint, that route is hard to defend: it preserves the score while weakening the equity dimension of the public-service mandate and the legitimacy on which future adjustments depend (Amanda & Kesuma, 2025; Apriono et al., 2023).

Loss reduction reconciles the two horns of this dilemma. By recovering saleable volume and lowering unit cost, a credible leakage-reduction program widens the margin for cost recovery without placing the full burden on tariffs so that any increase can be smaller and paired with demonstrable service improvement. Sequencing therefore matters as much as direction: reducing losses first and adjusting tariffs second turns the tariff conversation into a fair exchange of higher reliability for higher price (Schoeman & Chakwizira, 2023; Sumaryana et al., 2024).

Toward a Predictive, Project-Oriented Early-Warning System

An explicit boundary applies to this subsection. The empirical methodology ends with the Springate score and the DMA-level NRW diagnostics; the machine-learning tools noted here are not applied to the present data, are not validated on any Indonesian PDAM in this paper, and are offered solely as a recommendation for future research. A static model such as Springate could be complemented by a predictive-analytics platform in which an interpretable layer continuously monitors financial and operational indicators and attributes changes in continuity risk to specific drivers, such as leakage by area (Qi, 2025).

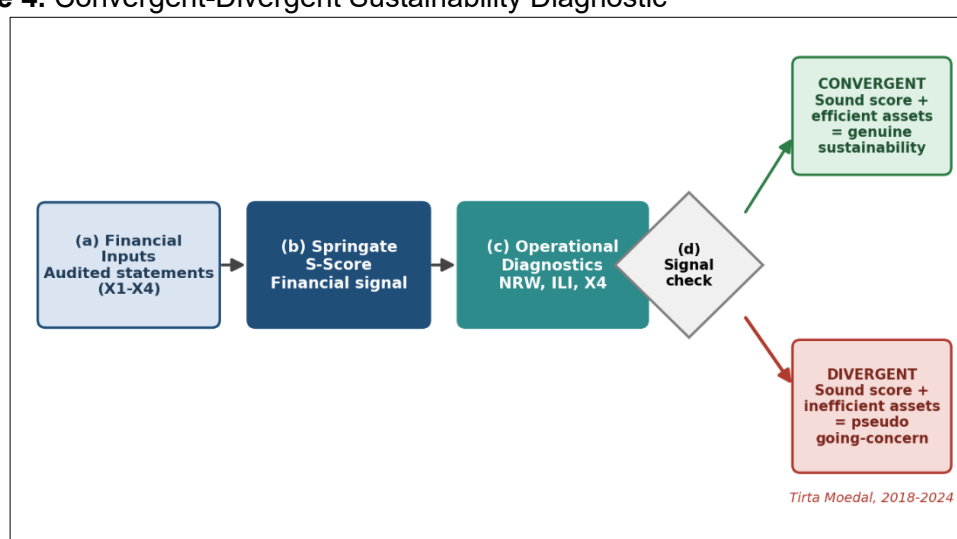
Robustness of the Pattern: Evidence from the Financial Ratios

Because the design compares patterns rather than estimating coefficients, robustness is assessed by triangulating the headline score against its component ratios (Yin, 2018). Three observations reinforce the pattern. First, the soundness is carried by solvency: the weighted solvency term rises from 0.37 in 2018 to about 1.13 in 2024, even as liquidity (X1) recedes from its 2021 peak of 0.43 to 0.21 under growing KPBU obligations, so the buffer does not depend on liquidity. Second, the efficiency channel is inert, with X4 within 0.57-0.69 and no upward trend, which is inconsistent with the rival reading that soundness reflects efficiency gains. Third, profitability and solvency strengthen while asset turnover stagnates and NRW worsens, so the divergence appears structural rather than an artifact of the weighting scheme.

A Conceptual Synthesis: The Qualified Paradox

Taken together, these analyses form the study's central conceptual contribution, summarized in Table 8 and Figure 4. The enterprise exhibits a qualified paradox: a financial signal that is sound yet only partially informative about sustainability. The observed health appears structurally insulated rather than efficiency-earned, so continuity is best described as a pseudo going-concern that holds while those supports hold. It is a qualified paradox rather than a contradiction, because the sound score and the failing network cease to be inconsistent once their common structural source is understood. Diagnostically, this is the divergent branch of Figure 4, which reframes financial-distress prediction, asset-efficiency monitoring, and project governance as three facets of a single continuity-management function.

Figure 4. Convergent-Divergent Sustainability Diagnostic



Note: The divergent branch describes the case of this study.

CONCLUSION

This study set out to determine whether the going-concern sustainability of a regional water enterprise, as signaled by the Springate model, is corroborated by the efficiency with which it uses its public assets. The evidence indicates a qualified paradox. On the accounting surface, Perumda Air Minum Tirta Moedal remained in the non-distress zone throughout 2018-2024, with scores between 1.0133 and 2.1347, above the 0.862 cut-off. Beneath that surface, the operational record is weak: non-revenue water reached 44.59% in 2024, and a critical cluster recorded an ILI in the worst international band. The two findings appear to share a common source. The financial soundness seems driven less by operational efficiency than by a natural-monopoly structure, tariff power over captive customers, and continuous fiscal support, reinforced by the West Semarang partnership, which keeps large investment debt off the balance sheet. Both propositions are therefore supported: the health is real but appears structurally insulated rather than efficiency-earned, and it is not aligned with the condition of the assets that ultimately generate value.

Framed through stewardship theory, this misalignment is the central caution of the study. A reassuring score read in isolation can become a source of false security, certifying the absence of imminent insolvency while remaining silent on the asset neglect accumulating behind it. For a monopolistic public utility, going-concern sustainability is better demonstrated not by a solvency figure that the market structure largely guarantees, but

by evidence that the steward is preserving and productively using the assets entrusted to it.

The study suggests that going-concern sustainability is strengthened by integrating financial discipline with optimization of physical-asset reliability. Practically, the enterprise may direct most of its non-PPP capital injection toward NRW reduction, namely rehabilitation of main distribution pipes and modernization of customer meters; replicate DMA-level loss-reduction projects combining structured methods with pressure and flow sensing; sequence tariff adjustment under the mayoral regulation so that cost recovery is paired with demonstrable reliability; and strengthen governance so that directors act as stewards of asset productivity. For future research, comparative testing across multiple PDAM and integration of operational variables into an explainable machine-learning early-warning system are recommended.

LIMITATION

This study has several limitations. First, the Springate model is based on coefficients estimated from Canadian listed firms in the 1970s, so its application to an Indonesian regulated monopoly should be interpreted contextually. Second, because the audited statements do not present EBIT separately, earnings before tax is used as the EBIT proxy in X2; although the substitution does not change the reported classifications, it should be considered when comparing the results with other studies. Third, the operational evidence is incomplete and partly non-public: annual NRW and ILI figures are not available for every year, the DMA diagnostic relies on an internal company document, and the city-wide loss estimate is based on stated utilization assumptions. Finally, the analysis is confined to a single entity, so the findings support analytic rather than statistical generalization. These limitations provide directions for future research using multiple BUMD, complete operational time series, and alternative or recalibrated distress models.

ACKNOWLEDGMENT

The authors express their gratitude to Perumda Air Minum Tirta Moedal, Semarang City, and to all parties who cooperated during this research.

DECLARATION OF CONFLICTING INTERESTS

The authors have declared no potential conflicts of interest concerning the study, authorship, and/or publication of this article.

REFERENCES

- Altman, E. I. (1968). Financial ratios, discriminant analysis, and the prediction of corporate bankruptcy. *The Journal of Finance*, 23(4), 589–609.
<https://doi.org/10.2307/2978933>
- Amanda, D., & Kesuma, S. A. (2025). A systematic literature review on stewardship theory (2020-2024). *International Journal of Social Science, Educational, Economics, Agriculture Research and Technology*, 4(12), 4290–4295.
<https://doi.org/10.54443/ijset.v4i12.1308>
- Ambarwati, S. D. A., Haryono, S. T., Fatmayuni, I. A., Nusanto, G., & Sukarno, A. (2025). Survival analysis: The impact of key factors on financial distress and longevity of real estate firms listed on the Indonesia Stock Exchange, with inflation as a moderating variable (2014-2023). *Indonesian Accounting Review*, 15(1), 47–58.
<https://doi.org/10.14414/tiar.v15i1.4917>
- Amelia, P., & Setiawan, C. (2022). Predicting financial distress using DEA and multivariate discriminant for tourism, restaurant, and hotel sector in Indonesia.

- Journal of International Conference Proceedings, 5(4), 172–184.
<https://doi.org/10.32535/jicp.v5i4.1936>
- Aprila, D., Andriani, W., & Ananto, R. P. (2023). Financial management of Nagari-Owned Enterprises (BUMNag) and its impact on community welfare. *Jurnal Akuntansi Bisnis*, 16(2), 210–225. <https://doi.org/10.30813/jab.v16i2.4461>
- Apriono, M., Fadah, I., Wardayati, S. M., Niken, R., Aprillianto, B., Wahyuni, N. I., & Awwaliyah, I. (2023). The effect of financial performance and environmental sensitivity on ESG disclosure: Empirical study in the agro-industrial sector. *International Journal of Applied Business and International Management*, 8(3), 56–71. <https://doi.org/10.32535/ijabim.v8i3.2531>
- Davis, J. H., Schoorman, F. D., & Donaldson, L. (1997). Toward a stewardship theory of management. *Academy of Management Review*, 22(1), 20–47. <https://doi.org/10.5465/amr.1997.9707180258>
- Goh, K. H., & See, K. F. (2023). Incorporating nonrevenue water in the efficiency assessment of water supply utilities: A parametric enhanced hyperbolic distance function. *Utilities Policy*, 81, 101483. <https://doi.org/10.1016/j.jup.2022.101483>
- Kingdom, B., Liemberger, R., & Marin, P. (2006). The Challenge of Reducing Non-Revenue Water in Developing Countries--How the Private Sector Can Help: A Look at Performance-Based Service Contracting (Water Supply and Sanitation Sector Board Discussion Paper No. 8). World Bank. <https://openknowledge.worldbank.org/handle/10986/17238>
- Lambert, A., & Hirner, W. (2000). *Losses from Water Supply Systems: Standard Terminology and Recommended Performance Measures*. IWA Publishing.
- Lestari, K. A. N. S., Lestari, E. P., & Astuty, S. (2024). The influence of the principles of good corporate governance, corporate social responsibility, and financial literacy on the financial performance of village credit institutions in the Negara District of Jembrana. *International Journal of Applied Business and International Management*, 9(1), 62–74. <https://doi.org/10.32535/ijabim.v9i1.2915>
- Machmud, Y. S., Nurlinah, N., Irwan, A. L., Saharuddin, S., & Irwan, A. I. U. (2023). The implementation of good governance principles in the asset management of regional-owned enterprises of South Sulawesi Province. *KnE Social Sciences*, 8(17), 840–856. <https://doi.org/10.18502/kss.v8i17.14182>
- Milleniasari, P. A., & Yunita, I. (2024). Analysis of bankruptcy prediction using Springate, Zmijewski, Grover, and Altman Z-Score models on retail companies listed on the Indonesia Stock Exchange. *International Journal of Science, Technology & Management*, 5(5), 1187–1200. <https://doi.org/10.46729/ijstm.v5i5.1176>
- Muzani, M., & Yuliana, I. (2021). Comparative analysis of Altman, Springate and Zmijewski models in predicting the bankruptcy of retail companies in Indonesia and Singapore. *International Journal of Applied Business*, 5(1), 81–93. <https://doi.org/10.20473/tijab.v5.i1.2021.81-93>
- Nanda, F. A., Masduqi, A., Ahyar, A., & Adhi, B. W. (2024). Analisis tingkat non-revenue water (NRW) pada jaringan distribusi SPAM pusat Perumda Air Minum Palangka Raya. *Jurnal Teknik Sipil Giratory*, 5(1), 1–10. <https://doi.org/10.26877/giratory.v1i1.19458>
- Naradipta, D. R., & Slamet, A. (2024). Analisa strategi penurunan kehilangan air dengan metode neraca air dan infrastructure leakage index (ILI) pada PERUMDA Delta Tirta Kabupaten Sidoarjo. *Jurnal Teknologi Lingkungan Lahan Basah*, 12(4), 1072–1082. <https://doi.org/10.26418/jtlb.v12i4.81665>
- Pemerintah Kota Semarang. (2025). Peraturan Wali Kota Semarang Nomor 4 Tahun 2025 tentang Tarif Air Minum pada Perusahaan Umum Daerah Air Minum Tirta Moedal Kota Semarang [Mayor of Semarang Regulation No. 4 of 2025 on Drinking Water Tariffs]. JDIH Kota Semarang. <https://jdih.semarangkota.go.id/>

- Perumda Air Minum Tirta Moedal Kota Semarang. (2025a). Laporan Keuangan Teraudit Periode 2018–2024 [Audited financial statements 2018–2024]. PDAM Kota Semarang. <https://www.pdamkotasmg.co.id/>
- Perumda Air Minum Tirta Moedal Kota Semarang. (2025b). Rencana Kerja dan Anggaran (RKA) Tahun 2025 [Work Plan and Budget 2025]. PDAM Kota Semarang. <https://www.pdamkotasmg.co.id/>
- Perumda Air Minum Tirta Moedal Kota Semarang. (2026). Profil perusahaan [Company profile]. PDAM Kota Semarang. <https://www.pdamkotasmg.co.id/>
- Pharmatrisanti, A., Purnomoadi, A., Purnomo, H., Naswil, S., Anugrahany, E., Mardiyasari, I., & Nugraha, H. (2023, November). Practical approach in setting asset management system and capability in a state-owned utility. In 2023 4th International Conference on High Voltage Engineering and Power Systems (pp. 21–24). IEEE. <https://doi.org/10.1109/ICHVEPS58902.2023.10257414>
- Qi, R. (2025, June). Enterprise financial distress prediction based on machine learning and SHAP interpretability analysis. In Proceedings of the 2025 International Conference on Artificial Intelligence and Digital Finance (pp. 76–79). Association for Computing Machinery. <https://doi.org/10.1145/3764727.3764740>
- Robiansyah, A., Yusmanianti, Y., Sari, I. K., Novrianda, H., & Irwanto, T. (2022). Analisis perbandingan model Altman, Springate, Zmijewski, dan Grover dalam memprediksi kebangkrutan perusahaan di Bursa Efek Indonesia (Studi Empiris Pada Perusahaan Manufaktur Yang Terdaftar di Bursa Efek Indonesia Periode 2012-2017). *Jurnal Ilmiah Ekonomi dan Bisnis*, 10(S1), 25–36. <https://doi.org/10.37676/ekombis.v10iS1.1957>
- Schoeman, I., & Chakwizira, J. (2023). Advancing a performance management tool for service delivery in local government. *Administrative Sciences*, 13(2), 31. <https://doi.org/10.3390/admsci13020031>
- Setiawan, C., & Gultom, F. V. (2025). Evaluating the effectiveness of financial distress prediction models in the property and real estate sector. *International Journal of Accounting and Finance in Asia Pasific*, 8(3), 350–368. <https://doi.org/10.32535/ijafap.v8i3.4132>
- Springate, G. L. V. (1978). Predicting the Possibility of Failure in a Canadian Firm [Unpublished master's thesis]. Simon Fraser University.
- Sumaryana, A., Komara, S. R., & Pancasilawan, R. (2024). Rethinking local government asset management in Indonesia: Governance, planning, and policy evaluation. *Journal of Contemporary Governance and Public Policy*, 5(2), 1–18. <https://doi.org/10.46507/jcgpp.v5i2.643>
- Wiedilaksono, A., Kurniasari, R. B., & Blois, R.-J. D. (2024). The role of Water Operator Partnership in accelerating adoption of new working process for non-revenue water reduction: A case study - Waterworx WOP between Perumda Air Minum Tirta Moedal and VEI. *Journal of Water, Sanitation and Hygiene for Development*, 14(11), 1030–1042. <https://doi.org/10.2166/washdev.2024.236>
- Wijayanto, C., Nurdiwaty, D., & Kurniawan, A. (2025). Analisis prediksi kebangkrutan menggunakan model Springate (S-Score) pada perusahaan telekomunikasi di Bursa Efek Indonesia 2020-2024. *Equivalent: Journal of Economic, Accounting and Management*, 3(2), 881–892. <https://doi.org/10.61994/equivalent.v3i2.1177>
- World Bank. (2025). Indonesia - National Urban Water Supply Project: Implementation Completion and Results Report. World Bank. <https://documents.worldbank.org/>
- Yin, R. K. (2018). Case Study Research and Applications: Design and Methods (6th ed.). SAGE Publications.

ABOUT THE AUTHOR

1st Author

Ady Setiawan holds a Doctorate in Management Science (Doktor Ilmu Manajemen) from Universitas Jember and serves as a lecturer in the Master of Management program at Universitas Teknologi Surabaya, Surabaya, Indonesia. His expertise lies in public-asset management and the financial governance of regional government-owned enterprises (BUMD), with particular attention to how the optimization of physical transmission and distribution assets safeguards the going-concern sustainability of public-service delivery. His research interests include public-asset optimization, non-revenue-water reduction, and financial-distress analysis as instruments for strengthening the long-term viability of public-service functions in the regional water sector.

Email: ady.setiawan@utssurabaya.ac.id

ORCID ID: <https://orcid.org/0009-0000-41,21-4652>