

Decision Informatics and Operational Efficiency in Regional Public Water Utilities: A Panel Data Approach

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Abstract. This study applies a data-driven panel analytical framework to examine seven operational determinants of financial performance in regional public water utilities across Jambi Province, Indonesia. Variables analyzed include population served, number of customers, operational costs, water sold, replacement of water meters, training costs, and employee expenses. Using the Fixed Effect Model (FEM), the results reveal that these factors jointly explain 84.9% of the variation in financial performance. However, the conventional scale–profitability relationship weakens under regulatory and operational constraints, indicating structural inefficiencies. Methodologically, this research contributes to decision informatics by demonstrating how panel data modeling can transform financial and operational metrics into actionable insights for management. The findings highlight the need for data-based pricing simulations, predictive dashboards, and digital monitoring systems to strengthen evidence-based decision-making. This approach not only enhances financial sustainability but also informs the design of smarter service systems and data-governed utility management in regional public sectors.

Keywords: Financial Performance, Data Analytics, Decision Informatics, Regional Utilities, Panel Data, Digital Governance

1. Introduction

The growing demand for clean and safe drinking water, driven by population growth and urbanization, has urged governments to improve the performance and governance of public water utilities. In Indonesia, this responsibility lies with regional governments, which operate through Regional Public Water Utilities (Perusahaan Umum Daerah Air Minum or Perumda Air Minum). These enterprises are mandated not only to ensure service continuity, quality, and affordability but also to maintain financial sustainability in accordance with Government Regulation No. 54 of 2017 (Pemerintah, 2017). However, many utilities still face managerial inefficiencies, high operational losses, and limited cost recovery that weaken both financial and service performance (BPKP, 2021).

Performance evaluations conducted by the Ministry of Public Works and Housing (PUPR) and the Financial and Development Supervisory Agency (BPKP) show that several utilities in Jambi Province have fluctuating financial outcomes. While some companies maintain healthy performance levels, others struggle with high non-revenue water, labor-intensive cost structures, and limited customer growth. These variations reflect unequal operational efficiency and data utilization capacity across the region.

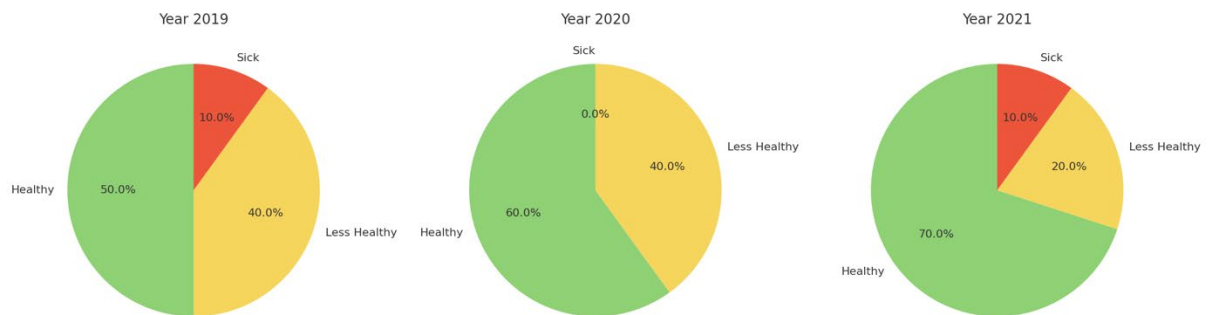


Fig.1: Performance of the Regional Public Water Utility Company in Jambi Province
Source: own research

The figure illustrates the variation in performance among regional public water utilities in Jambi Province between 2017 and 2021. Although most companies were categorized as healthy, several utilities such as Tirta Pengabuan, Tirta Sakti, and Tirta Muaro Jambi exhibited declining profitability, indicating rising financial stress and inefficiency. These differences underscore the need for analytical tools capable of identifying which operational factors drive financial performance variations. Consequently, the visual evidence in Figure 1 provides the empirical motivation for this study to examine, through a data-driven approach, how specific operational and human resource factors influence financial outcomes in regional public water utilities. Traditional evaluations of these utilities have focused mainly on financial indicators profitability, cost-recovery ratios, and liquidity without fully integrating non-financial or digital performance metrics. In the digital era, such an approach is no longer adequate. The management of public utilities increasingly depends on information systems and decision informatics, where data analytics serve as the backbone of performance improvement (Xu & Wang, 2022). Modern technologies such as Supervisory Control and Data Acquisition (SCADA) systems, Geographic Information Systems (GIS), IoT-based water metering, and integrated billing platforms produce vast streams of real-time data. Nevertheless, many local utilities have yet to transform these data into actionable insights for proactive decision-making (Liang & Zhang, 2021).

The absence of such integration contributes to information asymmetry between operational conditions and managerial oversight. According to Agency Theory (Jensen & Meckling, 1976) and Signaling Theory (Spence, 1973), the quality and transparency of information significantly affect organizational outcomes. Incorporating decision informatics into utility management enhances both

accountability and financial sustainability (Chou & Chen, 2023). Through analytical dashboards, predictive modeling, and performance simulation, utilities can evaluate service-expansion scenarios, cost structures, and tariff mechanisms more effectively forming the foundation of smart utility management. In this context, the present study applies a data-driven panel data model to quantify the relationships between operational variables population served, number of customers, operational costs, water sold, meter replacement, training costs, and employee expenses and the financial performance of regional public water utilities in Jambi Province from 2017 to 2021. Beyond empirical analysis, the research bridges public financial management with decision informatics, demonstrating how quantitative modeling can serve as a decision-support tool in optimizing efficiency and sustainability.

The core research problem is thus articulated as follows:

Although regional public water utilities generate large volumes of operational data, the absence of an integrated analytical framework prevents these data from being transformed into decision intelligence that can improve financial sustainability and service quality.

Accordingly, this study contributes to the field of service informatics and decision systems by developing a model that integrates financial and operational dimensions into a single, data-driven performance framework. The findings are expected to assist local governments and utility managers in transitioning from reactive management to evidence-based, digitally supported decision-making for enhanced public service outcomes.

The theoretical foundation of this study integrates perspectives from agency theory, signaling theory, financial performance analysis, and decision informatics to construct a comprehensive model for understanding the determinants of financial performance in regional public water utilities. According to Jensen and Meckling (1976), agency theory explains the contractual relationship between principals and agents, in which the owner (principal) delegates decision-making authority to a manager (agent). This separation often leads to information asymmetry and potential conflicts of interest when agents prioritize personal or short-term goals over organizational objectives. In the context of Perumda Air Minum, the local government acts as the principal, while the company management serves as the agent responsible for operational and financial outcomes. The success of this relationship depends heavily on information transparency and the quality of managerial reporting systems. When relevant data are incomplete, delayed, or distorted, agency costs increase, reducing efficiency and accountability (Tandiontong, 2016; Suryani Putri & NR, 2020). Thus, robust data systems and effective monitoring mechanisms become crucial to minimizing information asymmetry and ensuring that managerial actions align with public service goals.

Complementing this, Signaling Theory introduced by Spence (1973) posits that organizations send observable signals to external parties to convey their performance and credibility. For public utilities, financial statements, service reports, and digital dashboards act as key signals that reflect operational health. Positive signals such as improved profitability, service coverage, and efficiency enhance stakeholder confidence, while weak or inconsistent data communication may generate mistrust and uncertainty. Accordingly, utilities must ensure that operational and financial indicators are supported by accurate, timely, and transparent data processing. As Anderson, Fornell, and Lehmann (1994) emphasize, consistent and credible information contributes to customer trust, institutional legitimacy, and long-term profitability. From this theoretical standpoint, the variables tested in this research population served, customers, operating costs, water sold, meter replacement, training, and employee expenses function as signals that represent underlying operational effectiveness influencing financial performance.

Building upon these perspectives, financial performance itself represents a measurable outcome of managerial efficiency and organizational sustainability. Scholars such as Fahmi (2012), Rudianto (2013), and Kasmir (2016) define financial performance as the degree to which an organization utilizes its assets to generate profit and maintain liquidity. In regional public utilities, this involves balancing cost efficiency with service expansion, where excessive operational expenses, non-revenue

water, or labor inefficiency can weaken profitability (Widyanto, 2012; Zulkifli, 2020; Purba, 2020). However, traditional financial measures alone cannot capture the multidimensional nature of public service performance. As Mutia Basri (2015) highlights, non-financial indicators such as service coverage, customer satisfaction, and employee competency serve as leading predictors of future financial health. Therefore, integrating both financial and operational dimensions allows a more holistic understanding of utility performance under regulatory and social constraints.

To align with the focus of Logistics, Informatics, and Service Science (JLISS), this research extends the above theories by incorporating the lens of decision informatics and information systems theory. Decision informatics refers to the application of data analytics, computational modeling, and digital systems to support managerial decision-making (Chou & Chen, 2023). In the case of regional water utilities, large volumes of operational data covering customer usage, production capacity, maintenance schedules, and cost allocation can be transformed into actionable insights through modern analytical tools. According to Xu and Wang (2022), smart water systems use real-time sensors, IoT-based meters, and predictive analytics to optimize resource allocation and detect inefficiencies before they escalate. Likewise, Liang and Zhang (2021) demonstrate that IoT-based service systems enable utilities to connect physical operations with digital data monitoring, improving service reliability and responsiveness. In such frameworks, information quality and system integration are no longer auxiliary functions but core determinants of organizational performance. Poor data governance leads to delayed decisions and misallocation of resources, while advanced analytics and transparent reporting foster proactive management and financial stability.

In this study, the operational variables analyzed are viewed not merely as economic indicators but as information proxies that represent the organization's capacity to manage and interpret data effectively. For example, the number of customers and population served reflect the scale and accuracy of customer databases; training costs and employee expenses represent the firm's investment in knowledge management and data-driven competency; operational costs and water sold demonstrate how effectively resources are transformed into measurable financial outcomes. Integrating these components, the study constructs a conceptual model in which financial performance is influenced by operational efficiency, human resource capability, and the level of decision informatics maturity. This model aligns with agency theory by reducing information asymmetry through transparent reporting, with signaling theory by ensuring credible data dissemination, and with informatics theory by optimizing data utilization for strategic decision-making. Therefore, the proposed analytical framework bridges traditional financial management with modern digital governance, providing a holistic, data-driven understanding of how regional public utilities can enhance performance and accountability through integrated decision-support systems.

2. Research Method

This study employs a quantitative research approach utilizing secondary data analysis. The research object comprises Regional Public Drinking Water Companies (Perusahaan Umum Daerah Air Minum or Perumda) located in districts and cities across Jambi Province, Indonesia. An in-depth investigation is conducted to better understand the key issues and develop strategic solutions for enhancing financial performance.

Data Collection Techniques

The study uses a documentation method for data collection. Both primary and secondary data are utilized. Primary data are obtained from key informants closely related to the subject of study, while secondary data are collected from publicly accessible sources. The panel dataset covers the period from 2017 to 2021 and includes both time-series and cross-sectional elements. Time-series data are organized chronologically, while cross-sectional data capture multiple observations from different entities (e.g., companies or regions) at the same point in time.

Sources of secondary data include:

1. The Ministry of Public Works and Housing of Indonesia
2. The Indonesian Association of Drinking Water Companies (PERPAMSI) directory
3. Annual financial reports from each Perumda in Jambi Province

The collected data include company performance evaluations, operational metrics, and financial indicators relevant to assessing financial health and efficiency.

Research Objectives and Hypotheses

The primary objective of this study is to examine whether certain organizational and operational variables significantly influence financial performance. These variables include population served, number of customers, operational costs, water sold, replacement of water meters, training costs, and employee expenses.

The following hypotheses are proposed:

H1: Population served is positively and significantly associated with financial performance.

H2: Number of customers is positively and significantly associated with financial performance.

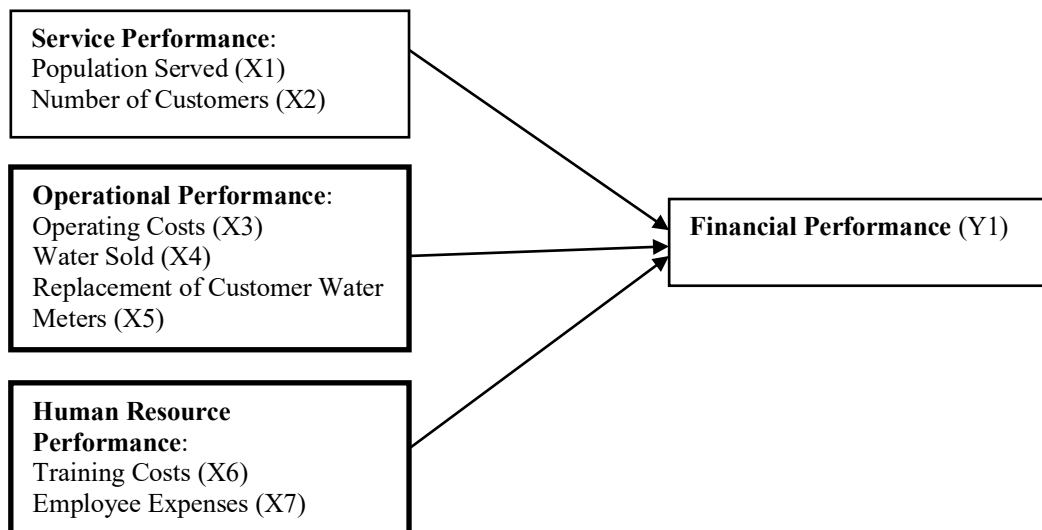
H3: Operational costs are negatively and significantly associated with financial performance.

H4: Water sold is positively and significantly associated with financial performance.

H5: Replacement of customer water meters is positively and significantly associated with financial performance.

H6: Training costs are positively and significantly associated with financial performance.

H7: Employee expenses are negatively and significantly associated with financial performance.



Source: own research

Fig.2: Graphical representation of the research model

To test the above hypotheses and identify the dominant factors influencing financial performance, a panel data multiple regression model is applied. The model specification is as follows:

$$Y_{it} = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \epsilon \quad (1)$$

where:

Y_{it} = Financial performance of Perumda i at time t

X_1 = Population served

X_2 = Number of customers

X3 = Operational costs
X4 = Water sold
X5 = Number of water meters replaced
X6 = Training costs
X7 = Employee expenses
 α = Constant
 β = Coefficients
 ϵ = Error term

3. Results And Discussion

Results

The estimation of panel data regression models can be conducted using three main approaches:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \dots + \beta_n X_{nit} + \mu_{it} \quad Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \dots + \beta_n X_{nit} + \mu_{it} \quad (2)$$

Table 1. Pooled Least Squares model (PLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1433369.	1262852.	1.135025	0.2637
X1	-10.66770	9.614926	-1.109493	0.2744
X2	100.0979	81.98633	1.220909	0.2298
X3	-0.311877	0.069882	-4.462884	0.0001
X4	0.366651	0.083060	4.414283	0.0001
X5	-685.0109	231.7143	-2.956273	0.0054
X6	0.009886	0.005143	1.922318	0.0623
X7	-0.804505	0.284572	-2.827068	0.0075
R-squared	0.780429	Mean dependent var		-1082004.
Adjusted R-squared	0.738889	S.D. dependent var		4144089.
S.E. of regression	2117591.	Akaike info criterion		32.12927
Sum squared resid	1.66E+14	Schwarz criterion		32.45045
Log likelihood	-714.9085	Hannan-Quinn criter.		32.24900
F-statistic	18.78720	Durbin-Watson stat		1.693668
Prob(F-statistic)	0.000000			

Source: own research

This model shows that the constant term β_0 for the Regional Public Drinking Water Companies (Perumda Air Minum) in regencies and cities across Jambi Province is 1,433,369. Based on the estimation results, four independent variables are found to significantly influence the dependent variable.

Fixed Effect Model (FEM)

This model assumes that the slope coefficients are constant across entities, while the intercept varies among them. The variation in intercepts is accounted for using dummy variables. The regression equation is as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 D_{1i} + \beta_4 D_{2i} + \dots + \epsilon_{it} \quad Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 D_{1i} + \beta_4 D_{2i} + \dots + \epsilon_{it} \quad (3)$$

Table 2. Estimation Results of the Fixed Effect Panel Data Regression Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11140030	2712000.	4.107681	0.0003
X1	-15.72798	8.201029	-1.917806	0.0650
X2	-318.5135	121.4332	-2.622953	0.0138
X3	-0.198884	0.060006	-3.314379	0.0025
X4	0.398865	0.098779	4.037953	0.0004
X5	-667.3695	222.0376	-3.005660	0.0054
X6	0.012622	0.006354	1.986353	0.0565
X7	-1.520638	0.278817	-5.453885	0.0000
Fixed Effects (Cross)				
BATANGHARI--C	109978.1			
BUNGO—C	-3582972.			
KERINCI—C	8119181.			
KOTAJAMBI—C	15162626			
MERANGIN—C	-4449561.			
MUAROJAMBI--C	-4252361.			
SAROLANGUN--C	-4882135.			
TANJABBARAT--C	-4039880.			
TEBO—C	-2184878.			
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.900795	Mean dependent var	-1082004.	
Adjusted R-squared	0.849481	S.D. dependent var	4144089.	
S.E. of regression	1607771.	Akaike info criterion	31.69034	
Sum squared resid	7.50E+13	Schwarz criterion	32.33271	
Log likelihood	-697.0327	Hannan-Quinn criter.	31.92981	
F-statistic	17.55484	Durbin-Watson stat	2.281150	
Prob(F-statistic)	0.000000			

Source: own research

From Table 2 of this study, it can be observed that seven individual variables (X1, X2, X3, X4, X5, X6, and X7) are statistically significant, with significance levels exceeding $\alpha = 10\%$. The Adjusted R-squared value of 0.849481 indicates a strong explanatory power, supported by a high R-squared value of 0.900795. The F-statistic probability value of 0.000000 suggests that the model is highly significant. Moreover, the Durbin-Watson statistic of 2.281150 falls within the acceptable range above 2, indicating no serious autocorrelation issues. The next stage of analysis requires the application of the Random Effect Model.

This model assumes that the differences across individuals are explained by a random error component. The regression equation is as follows:

$$Y_{it} = \beta_0 + \mu_i + \beta_1 X_{1it} + \beta_2 X_{2it} + e_{it} \quad (4)$$

Table 3. Random Effect Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1601874.	1018002.	1.573547	0.1241
X1	-10.79536	7.337723	-1.471213	0.1497
X2	90.16448	65.14170	1.384128	0.1746
X3	-0.300782	0.054055	-5.564375	0.0000
X4	0.363128	0.065681	5.528630	0.0000
X5	-684.7655	179.3995	-3.816987	0.0005
X6	0.010744	0.004135	2.598446	0.0134
X7	-0.844266	0.220591	-3.827284	0.0005
Random Effects (Cross)				

BATANGHARI--C	243747.0				
BUNGO--C	68897.37				
KERINCI--C	290529.8				
KOTAJAMBI--C	-34228.11				
MERANGIN--C	-247396.8				
MUAROJAMBI--C	-303935.4				
SAROLANGUN--C	-262142.6				
TANJABBARAT--C	40628.96				
TEBO--C	203899.7				
Effects Specification					
			S.D.		Rho
Cross-section random			383534.6		0.0538
Idiosyncratic random			1607771.		0.9462
Weighted Statistics					
R-squared	0.778491	Mean dependent var			-954677.3
Adjusted R-squared	0.736583	S.D. dependent var			4016868.
S.E. of regression	2061622.	Sum squared resid			1.57E+14
F-statistic	18.57655	Durbin-Watson stat			1.707457
Prob(F-statistic)	0.000000				
Unweighted Statistics					
R-squared	0.779477	Mean dependent var			-1082004.
Sum squared resid	1.67E+14	Durbin-Watson stat			1.611408

Source: own research

Based on the estimation results using the Random Effect Model for the financial performance of regional public drinking water companies in Jambi Province, the R^2 value obtained is 0.779477. This means that 77.9477 percent of the variation in the financial performance of the regional public drinking water companies in Jambi Province can be explained by the independent variables included in the model.

Selection of Panel Regression Model

Test Chow

It is used to compare the Common Effect Model (CEM) and the Fixed Effect Model (FEM). If the F-statistic value is greater than the F-table value, then the Fixed Effect Model (FEM) is considered more appropriate to use.

Table 4. Test Chow

Effects Test	Statistic	d.f.	Prob.
Cross-section F	4.398195	(8,29)	0.0014
Cross-section Chi-square	35.751712	8	0.0000

Source: own research

Based on the display above, attention should be focused on the topmost table, which shows that the probability value of the Cross-section F is 0.0014, which is less than 0.05. Therefore, it can be concluded that the Fixed Effect Model (FEM) is more appropriate than the Common Effect Model (CEM).

Test Hausman

It is used to determine the choice between the Fixed Effect Model (FEM) and the Random Effect Model (REM). If the Chi-square probability value is less than 0.05, then FEM is more appropriate. Conversely, if the value is greater than 0.05, REM is more suitable.

Table 5. Test Hausman

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	30.837507	7	0.0001

Source: own research

Ultimately, based on the Hausman statistical test, the most appropriate model for analyzing the panel data in this study is the Fixed Effect Model (FEM). In line with the research methodology, this model is used to analyze the extent to which variables X1, X2, X3, X4, X5, X6, and X7 affect Y the financial performance of the Regional Drinking Water Companies (Perusahaan Umum Daerah Air Minum) in Jambi Province. The method applied is a multiple linear panel regression using the selected Fixed Effect Model (FEM), which involves pooled or panel data, analyzed using EViews version 8.0. Based on the estimation results, the regression equation is formulated as follows:

$$Y_{it} = 11140030 - 15.72798X_{1it} - 318.8135X_{2it} - 0.198884X_{3it} + 0.398865X_{4it} - 667.3695X_{5it} + 0.012622X_{6it} - 1.520638X_{7it} + \mu_i$$

Test F (Simultan)

This test is used to examine the joint effect of all independent variables. If the calculated F-value is greater than the F-table value or if the significance value is less than 0.10, then the model is considered statistically significant. At a significance level of $\alpha = 10\%$ with degrees of freedom (df) = 45 ($n = 45 - 7$), the F-table value is obtained. The calculated F-value is 63.315, which is greater than the F-table value of 2.750. This result leads to the rejection of the null hypothesis (H_0) and acceptance of the alternative hypothesis (H_1). This conclusion is further supported by the probability value of the F-statistic (Prob. F-statistic) = 0.000, which is less than 0.10. Therefore, H_0 is rejected and H_1 is accepted, indicating that, jointly, the variables X1 (Population Served), X2 (Number of Customers), X3 (Operational Costs), X4 (Water Sold), X5 (Number of Replaced Water Meters), X6 (Training Costs), and X7 (Employee Expenses) have a significant effect on the financial performance of Regional Drinking Water Companies (Perusahaan Umum Daerah Air Minum) in Jambi Province during the period 2017–2021.

Table 6. Test F

Statistic	Value
F-Statistic	63.315
Prob (F-statistic)	0.00000
R-squared	0.900795
Adjusted R-squared	0.849481
Durbin-Watson stat	2.281150
Significance Level	10% ($\alpha = 0.10$)
F-table (df = 7,45)	≈ 2750

Source: own research

Test t

This test is used to examine the individual effect of each independent variable on the dependent variable. If the calculated t-value is greater than the t-table value or if the significance level is less than 0.10, then the variable is considered statistically significant.

Table 7. Test Parsial (Test t)

Variabel	Prob.	Significant <10%
Population Served (X1)	0.0650	Significant
Number of Customers (X2)	0.0138	Significant
Operational Costs (X3)	0.0025	Significant
Water Sold (X4)	0.0004	Significant
Replaced Water Meters (X5)	0.0054	Significant
Training Costs (X6)	0.0565	Significant
Employee Expenses (X7)	0.0000	Significant

Source: own research

Summary of Empirical Findings and Model Interpretation

To enhance clarity, the main empirical results are summarized in the following table, highlighting coefficient directions, significance levels, and hypothesis support status.

Table 8. Summary of Hypothesis Testing Results

Independent Variable	Direction	Significance ($p < 0.10$)	Result	Hypothesis Status
X1 – Population Served	Negative	0.0650	Significant	Supported
X2 – Number of Customers	Negative	0.0138	Significant	Supported
X3 – Operational Costs	Negative	0.0025	Significant	Supported
X4 – Water Sold	Positive	0.0004	Significant	Supported
X5 – Replaced Water Meters	Negative	0.0054	Significant	Supported
X6 – Training Costs	Positive	0.0565	Significant	Supported
X7 – Employee Expenses	Negative	0.0000	Significant	Supported

Source: Processed data (EViews output, 2024)

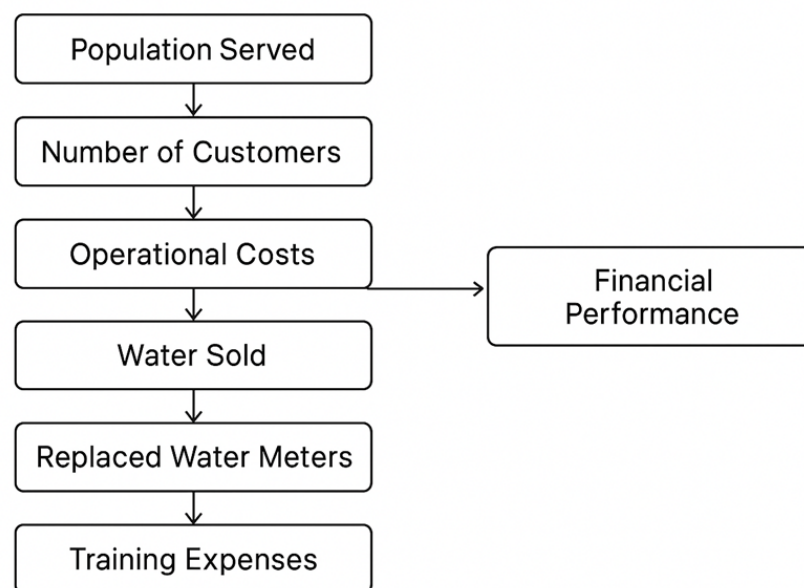


Fig.3: Interrelationship between Variables and Financial Performance

The selected Fixed Effect Model (FEM) demonstrates strong explanatory power with an Adjusted R^2 of 0.849 and a highly significant F-statistic (Prob = 0.000000). The Durbin Watson value (2.281) indicates no serious autocorrelation, confirming model reliability. Both the Chow and Hausman tests support the FEM as the most suitable specification, suggesting systematic differences among companies that must be controlled for statistically. Overall, the diagnostic results confirm the robustness and goodness-of-fit of the model. Operational and human resource factors jointly shape the financial performance of regional water utilities, reflecting a balanced interaction between efficiency and service outcomes

Discussion

Population Served (X1) and Financial Performance (Y)

The discussion begins by assessing the model's ability to explain the variation in financial performance, where the Adjusted R-squared value of 0.849481 and R-squared of 0.900795 indicate a strong explanatory power. With a probability value of the F-statistic at 0.000000 and a Durbin-Watson statistic of 2.281150, the model is considered highly significant and free from autocorrelation. This suggests that the independent variables used namely Population Served (X1), Number of Customers (X2), Operational Costs (X3), Water Sold (X4), Replaced Water Meters (X5), Training Costs (X6), and Employee Expenses (X7) jointly explain 85% of the variance in financial performance, leaving 15% to be influenced by other factors not included in the study.

Based on the partial test (t-test), the number of people served (X1) has a significant impact on financial performance. A broader market share improves profitability, as it reflects the company's capability to meet the community's basic water supply needs. This finding aligns with prior research by Wernerfelt (2001), Etale et al. (2016), Felania Rinta Maharani et al. (2021), Mardillasari et al. (2021), Lim & Rokhim (2020), Yudhaningsih & Elik Astari (2020), and Purba (2020), all of whom emphasized the relationship between market share and profitability. However, limitations in distribution networks and the high cost of installation, along with socio-economic challenges, hinder wider service coverage in regional drinking water companies in Jambi Province.

The number of customers (X2) also significantly influences financial performance. This is consistent with studies by Yulia et al. (2018), Mashuri & Mardianis (2020), Fahira Rizki Amaliana (2023), and Purba (2020). A larger customer base boosts revenue potential, although it must be supported by effective billing systems and service quality to maintain profitability. If many customers fail to pay their bills, financial deficits may arise, forcing companies to focus on improving service and production quality.

Operational costs (X3) were found to significantly impact financial performance, where increased costs correspond to decreased net profit. This outcome supports the findings of Zulkifli (2020), Widyanto (2012), Ujang Suhaimi (2021), Rahmawati & Kosasih (2020), Carolina et al. (2022), and Purba (2020), all of whom identified operating expenses as a key factor in net profit reduction.

Water sold (X4) plays a critical role in determining financial outcomes. The more water sold, the greater the revenue, although in the case of regional drinking water companies in Jambi Province, operational revenues remain lower than operating costs. This condition, influenced by factors such as customer consumption patterns, water loss, meter reading accuracy, and tariff structure, contributes to financial losses. The findings are consistent with those of Yulia et al. (2018), Ujang Suhaimi (2021), and Purba (2020), who emphasized that revenue from water sales significantly impacts profitability.

Replaced water meters (X5) also have a significant effect on financial performance. Studies by Amalia (2022) and Purba (2020) highlight that replacing outdated or malfunctioning meters reduces water loss, improves pressure uniformity, and enhances service efficiency, ultimately leading to increased revenue. Meter replacement ensures more accurate billing and a more reliable customer database, all of which contribute positively to financial performance.

Training costs (X6) influence financial performance as well, as supported by Setiawan et al.

(2022), Gigih Yuli Asmara & Handoko (2020), and Purba (2020). Training investment reflects knowledge management within the organization. Well-trained employees with a strong understanding of their responsibilities are more efficient and contribute to improved organizational outcomes, thereby enhancing financial performance. Lastly, employee expenses (X7) significantly impact financial performance. The studies of Fulop (2021), Topor et al. (2022), and Purba (2020) confirm that high employee costs influence profitability, particularly in organizations with excessive or underqualified staff. In regional drinking water companies, an imbalance between personnel costs and productivity leads to financial inefficiency and persistent losses, especially when labor expenses represent a large portion of operating costs.

The empirical findings of this study reveal a paradox: while the expansion of service coverage and customer base should, in principle, enhance profitability, many regional public water utilities in Jambi Province still experience declining financial performance. Using institutional theory, this can be understood as a structural constraint where normative and regulatory pressures to expand services often outweigh economic rationality and data-driven decision-making. Consequently, expansion tends to increase operational complexity and costs without a corresponding improvement in revenue. However, from an informatics perspective, this paradox can be mitigated through the systematic use of data-driven decision systems. The weak profitability associated with expansion is partly due to data fragmentation and the absence of predictive analytics capable of anticipating financial and operational impacts. Current reporting practices remain reactive focusing on historical performance rather than predictive and prescriptive in guiding managerial strategy.

To address these limitations, integrating decision dashboards and simulation-based financial models can transform operational oversight. For instance, a tariff simulation model could estimate cost-recovery levels under varying demand and price elasticity conditions, enabling local governments and Perumda managers to assess optimal pricing strategies without compromising affordability. Similarly, data-driven efficiency benchmarking techniques, such as Data Envelopment Analysis (DEA), Partial Least Squares Path Modeling (PLS-PM), or AI-based predictive models, can identify inefficiencies across utilities and suggest specific interventions for cost optimization. Moreover, the adoption of digital twin technology a virtual replica of the physical utility network offers significant potential. By constructing a digital twin of the water distribution system, managers can simulate the financial and technical impacts of network expansion, leakage control, and maintenance scenarios before implementing them in real operations. This aligns with the broader movement toward smart utility management, where informatization enhances transparency, predictive accuracy, and service reliability. Integrating these informatics tools shifts the role of financial reporting and operational monitoring from descriptive to decision-supportive analytics. As illustrated by the conceptual framework, such integration transforms the management paradigm: "Integrating IT tools such as digital dashboards and predictive analytics can help utility companies simulate cost recovery outcomes across different rate and coverage scenarios, transforming reactive reporting into proactive decision support."

In this context, informatics not only bridges institutional constraints but also establishes a data-governance culture that promotes adaptive learning, transparency, and accountability key foundations for sustainable performance improvement in regional public utilities. Recent studies emphasize that integrating service informatics and digital decision systems can enhance the financial and operational resilience of public utilities. As noted by Chou and Chen (2023), digital analytics transform traditional management into evidence-based, real-time decision frameworks. Similarly, Xu and Wang (2022) show that smart water systems using data-driven optimization improve efficiency through predictive tariff and demand modeling. The adoption of IoT-based service systems (Liang & Zhang, 2021) allows continuous monitoring of water networks, while digital twins enable utilities to simulate expansion and maintenance scenarios before implementation (Kim et al., 2022). Furthermore, AI-based decision support promotes automated diagnostics and data-informed governance (Gupta &

Rana, 2023). Collectively, these approaches highlight that informatization transforms reactive financial management into proactive, predictive, and sustainable service delivery.

4. Conclusion

This study identifies and quantifies the key organizational, operational, and human resource factors influencing the financial performance of Regional Drinking Water Companies (Perumda Air Minum) in Jambi Province using a panel data regression approach. The results confirm that variables such as population served, number of customers, operational costs, water sold, replacement of water meters, training costs, and employee expenses jointly and significantly affect financial performance. The Fixed Effect Model (FEM), selected as the most appropriate specification, explains 84.9% of the variation in financial performance with a high degree of reliability and diagnostic soundness. Beyond its empirical contribution, this study provides valuable informational and managerial insights. The use of panel data analysis demonstrates how longitudinal and cross-sectional information can be transformed into decision-support analytics that help managers detect efficiency patterns, evaluate cost structures, and design data-informed strategies for improving financial sustainability in public utilities. The findings thus contribute to service informatics, illustrating how quantitative data modeling can link operational dynamics to financial outcomes, enabling evidence-based decision-making. From a managerial standpoint, the study underscores the importance of integrating digital monitoring systems, predictive analytics, and performance dashboards into water utility management. These tools can enhance the timeliness and accuracy of financial diagnostics and support proactive intervention. Looking forward, future research should explore the integration of Artificial Intelligence (AI), Internet of Things (IoT)-based sensors, and real-time analytics platforms to continuously monitor service efficiency, predict cost-recovery potential, and optimize tariff and investment decisions. In summary, this research bridges the empirical analysis of financial performance with emerging directions in data-driven governance, providing a conceptual and analytical foundation for the development of smarter, more adaptive, and accountable public utility management systems.

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