Variance
Journal of Statistics and Its Applications
P-ISSN: 2685-8738 E-ISSN: 2685-872X

Variance: Journal of Statistics and Its Applications
Volume 7 Issue 2 | October 2025
10.30598/variancevol7iss2page187-198

ANALYSIS OF INVESTMENT RISK IN MALUKU PROVINCE USING MEAN-VARIANCE APPROACH ON LOCAL OWN-SOURCE REVENUE (PAD)

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Abstract: *This study aims to analyze investment risks in Maluku Province using the Mean-Variance approach on the Local Own-Source Revenue (PAD) data. The method used in this study is a quantitative analysis of time-series data on PAD from 2015 to 2022. The mean-variance model is used to calculate the rate of return and risk of each PAD component and to construct an efficient frontier as a basis for optimal decision-making. The results show that the regional tax PAD component offers a high rate of return with relatively low risk, potentially making it a stable source of revenue for local governments. These findings provide a basis for optimizing PAD allocation to improve fiscal stability and the sustainability of regional development.*

Keywords: *investment, local own-source revenue, Maluku, mean-variance, PAD*

1. INTRODUCTION

The Central Government, through Law No. 23 of 2014 concerning Regional Government, has given regional governments a broad mandate to manage their fiscal potential independently. The goal is to strengthen regional autonomy by increasing fiscal capacity, thereby encouraging financial independence, accelerating local economic growth, and providing public services that are more responsive to community needs [1]. In the context of fiscal decentralization, Local Own-Source Revenue (PAD) is a key component that reflects a region's ability to finance development without excessive dependence on transfers from the central government. However, conditions on the ground do not fully reflect this ideal. Most local governments in Indonesia still face obstacles in optimally tapping their PAD potential due to narrow local economic structures, weak tax and levy administration systems, and low taxpayer compliance [2]. This situation has led to high fiscal dependence on the General Allocation Fund (DAU) and the Special Allocation Fund (DAK), particularly in regions with non-industrial economic bases, such as Maluku and Papua. Furthermore, the effectiveness of regional public spending has not yet achieved the desired level of efficiency, as the majority of the budget is still allocated to routine spending rather than productive spending that can drive economic growth.

As an archipelagic region with unique geographic, demographic, and economic characteristics, Maluku Province faces unique complexities in regional fiscal management. Its geographical location, comprising numerous small islands, coupled with limited transportation and communication infrastructure, hampers equitable development and the equitable distribution of fiscal resources. Furthermore, Maluku's economic structure is still dominated by primary sectors such as fisheries, agriculture, and forestry, making its fiscal resilience vulnerable to changes in external conditions, including global commodity prices and climate dynamics, which ultimately affect production in these sectors. Economic disparities between regions also exacerbate the fiscal capacity gap, as most economic activity is concentrated in urban areas such as Ambon. In contrast, other island regions remain dependent on fiscal transfers from the central government to support basic development needs [3][4].

The PAD data reported by the Central Statistics Agency (BPS) of Maluku Province for the 2015–2022 period reveal inconsistent growth across components. Regional taxes account for the largest share of PAD but remain exposed to macroeconomic volatility, while revenues from asset management and retributions fluctuate sharply. These observations indicate two primary fiscal challenges: (1) high volatility in overall

 Submitted: 2025-10-27 *Accepted:2025-11-14*

PAD performance and (2) dependence on a limited number of revenue sources. Such conditions highlight the need for a systematic, diversification-based strategy to stabilize regional fiscal capacity [5], [6], [7], [8].

Although Local Own-Source Revenue (PAD) is not a tradable financial asset, its components exhibit measurable patterns of growth and volatility over time. By redefining "return" as the annual growth rate of PAD and "risk" as its fluctuation, the Mean-Variance model can be adapted to assess fiscal efficiency. This analytical perspective aligns with previous studies that applied portfolio theory to public finance to evaluate the stability of government revenue structures [9][10]. Hence, the Mean-Variance approach is conceptually relevant for examining how local governments can diversify PAD components to minimize fiscal uncertainty while maintaining sustainable revenue growth. In this analytical framework, local governments are viewed as portfolio managers who allocate resources among various revenue components to balance stability and growth, similar to how investors manage assets in a financial portfolio.

Empirical studies on regional fiscal performance in Indonesia have largely focused on western regions, such as Java and Sumatra [2][4], while research applying quantitative risk-based analysis is still limited to eastern Indonesia. Although Marselina et al (2023) evaluated fiscal management in Maluku, their study did not quantitatively examine the relationship between risk and return across local revenue components. Therefore, this study fills this empirical gap by applying the Mean-Variance model to Maluku Province as a case study in eastern Indonesia.

Accordingly, this study aims to: (1) calculate the rate of return and risk for each component of Maluku Province's PAD using the Mean-Variance approach; (2) construct an efficient frontier and determine the optimal composition of PAD components; and (3) interpret the fiscal implications of the resulting portfolio for regional revenue stability. Theoretically, this study extends portfolio theory into public finance by offering insights for local fiscal authorities to enhance PAD diversification, improve revenue predictability, and reduce dependence on single revenue sources, thereby strengthening long-term fiscal sustainability.

2. METHODOLOGY

2.1 Theoretical Framework

This research uses the Markowitz Mean-Variance Model to analyze the components of Local Own-Source Revenue (PAD). In this analogy, each PAD component is treated as a financial asset in an investment portfolio. The primary objective is to find the optimal combination of various PAD components that minimizes risk for a given level of return or maximizes return for a given level of risk.

2.2 Data Sources

The data used in this study is Maluku Province's Local Own-Source Revenue (PAD). This data is secondary, taken from the official website of the Maluku Province Statistics Agency (BPS). The four components of PAD that were analyzed were:

1) Regional Taxes (T)
2) Regional Levies (L)
3) Proceeds from Management of Separated Regional Assets (A)
4) Other Legitimate Regional Income (I)

2.3 Variables and Mathematical Notations

The following are the variables and notations used in this study.

i : Index for PAD component, $i = 1,2,3,4$

t : Index for year $t = 1,2,3,\cdots,T$ where $T = 7$ because returns are calculated from 2016 to 2022

$PAD_{i,t}$: Value of the i-th PAD component in year t

$PAD_{i,t-1}$: Value of the i-th PAD component in year $t-1$

$R_{i,t}$: Annual return of the i-th PAD component in year t

$E(R_i)$: Expected return of component i

σ_i : Standard deviation (risk) of component i

$\sigma_{i,j}$: Covariance between the returns of the i-th and j-th PAD components

w_i : Allocation weight for the i-th PAD component

$E(R_p)$: Expected return of the portfolio

σ_p : Portfolio risk

S : Sharpe ratio

R_f : Risk-free

2.4 Quantitative Analysis

2.4.1 Individual Return Calculation

Return is the profit or rate of return obtained from the investment of an asset. In the context of PAD asset management, the annual return for each PAD component is calculated as the percentage change in its current value from the previous year [11]. Mathematically, the rate of return for each PAD component can be expressed as follows:

$$R_{i,t} = \frac{PAD_{i,t} - PAD_{i,t-1}}{PAD_{i,t-1}} \tag{1}$$

2.4.2 Calculation of Expected Return and Individual Risk

The average rate of return, or expected return, is a weighted average of historical returns [11]. The expected return for each PAD component can be calculated as:

$$E(R_i) = \frac{1}{T}\sum_{t=1}^{T} R_{i,t} \tag{2}$$

Meanwhile, the risk measure (variance) for each PAD component is calculated as:

$$\sigma_i^2 = \frac{1}{T-1}\sum_{t=1}^{T}\left(R_{i,t} - E(R_i)\right)^2 \tag{3}$$

$$\sigma_i = \sqrt{\sigma_i^2} \tag{4}$$

2.4.3 Calculation of Covariance and Correlation Matrix

The variance of a portfolio's return is more dependent on the covariances among the individual securities than on their variances. In the context of PAD, the covariance value provides quantitative information about how changes in one PAD component will affect other components. This allows for more realistic projections. This value is calculated using the following formula [12]:

$$\sigma_{i,j} = \frac{1}{T-1}\sum_{t=1}^{T}\left(R_{i,t} - E(R_i)\right)\left(R_{j,t} - E(R_j)\right) \tag{5}$$

All these covariance values are then arranged into a Covariance Matrix $\Sigma \in R^{4\times 4}$, where the elements are $\sum_{i,j} = \sigma_{i,j}$. This covariance matrix is what then becomes the basis for calculating quantitative diversification strategies.

2.4.4 Optimal Portfolio formulation

PAD portfolio is defined as a linear combination of the four PAD components with weights $w = (w_1, w_2, w_3, w_4)^T$ and the vector of expected returns for all assets is $\mu = \left(E(R_1), E(R_2), E(R_3), E(R_4)\right)^T$. Then the expected portfolio return is the weighted average of the individual returns of each PAD component forming the portfolio which can be expressed as [13]:

$$E\left(R_p\right) = (w^T \mu) \tag{6}$$

The variance (squared risk) of a portfolio is a function of the weights and the covariance matrix and can be expressed as:

$$\sigma_p^2 = \sum_{i=1}^{4} \sum_{j=1}^{4} w_i w_j \sigma_{i,j} = w^T \Sigma w \tag{7}$$

with the main constraint that the total weight allocation must be 100% or $\sum_{i=1}^{4} w_i = 1$.

2.4.5 Portfolio Optimization: Minimum Variance and Efficient Frontier

1) Minimum Variance Portfolio

Minimum Variance Portfolio (MVP) is a combination or allocation of assets that produces the lowest (minimum) level of risk that can possibly be achieved from all possible portfolios. In this context, MVP is the ideal composition of the four PAD components that makes the total regional income fluctuations the most stable and smallest. MVP is found by solving a mathematical optimization problem.

$$min \frac{1}{2} w^T \Sigma w \tag{8}$$

with the subject to

$$w^T 1 = 1, \tag{9}$$

The optimization process is carried out by minimizing the objective function in Equation (8), which represents half of the portfolio variance with constraints $w^T 1 = 1$ and $w > 0$. Next, create a Lagrangian function:

$$\mathcal{L}(w_1, w_2, w_3, w_4, \lambda) = \frac{1}{2} w^T \Sigma w + \lambda(1 - w^T 1) \tag{10}$$

To obtain the optimal condition, the function is derived partially with respect to w and λ:

Partial derivatives of w :

$$\frac{\partial \mathcal{L}}{\partial w} = \Sigma \mathrm{w} - \lambda 1 = 0 \rightarrow \Sigma \mathrm{w} = \lambda 1 \tag{11}$$

Partial derivatives of λ :

$$\frac{\partial \mathcal{L}}{\partial \lambda} = (1 - w^T 1) = 0 \rightarrow w^T 1 = 1 \tag{12}$$

From Equation (11), we get:

$$\mathrm{w} = \lambda \Sigma^{-1} 1 \tag{13}$$

Next, substitute Equation (13) to Equation (12):

$$(\lambda\Sigma^{-1}1)^T 1 = 1$$
$$(\lambda 1)^T \Sigma^{-1} 1 = 1$$
$$\lambda = \frac{1}{1^T \Sigma^{-1} 1} \tag{14}$$

From Equation (14) the final solution is obtained to calculate the optimal MVP weight [14]:

$$\mathrm{w}_{MVP} = \frac{\Sigma^{-1} 1}{1^T \Sigma^{-1} 1} \tag{15}$$

2) Efficient Frontier

The set of all efficient portfolios, that is, portfolios that provide the maximum expected return for a given level of risk, or the minimum risk for a given level of expected return. This frontier is derived by solving a parametric optimization problem for various target returns μ_p. The efficient frontier is a curve that shows the optimal combination of investment portfolios. Portfolios along this curve offer the highest expected return for a given level of risk or the lowest risk for a given level of expected return. On the efficient frontier curve, the horizontal axis indicates the magnitude of the risk, while the vertical axis indicates the level of return. The Efficient Frontier curve is then plotted in risk-return space (σ_p, μ_p)[14].

2.4.6 Optimal Portfolio with Maximum Sharpe Ratio

Practically optimal portfolios are often sought to maximize the Sharpe Ratio, which measures excess return per unit of risk. In this study, the sharpe ratio was selected based on the unique characteristics of the PAD portfolio, which lacks a clear market benchmark, rendering the Treynor Ratio and Jensen's Alpha inapplicable. Unlike stock portfolios, which use a market index as a reference, PAD, as a regional revenue portfolio, requires measurement of total risk rather than just systematic risk. The Sharpe Ratio can independently measure portfolio efficiency without relying on beta or market returns, while also providing regional policymakers with an intuitive interpretation of the return per unit of risk assumed. The Sharpe ratio measures portfolio efficiency by comparing the portfolio's return to its total risk (standard deviation). The higher the Sharpe ratio, the better the portfolio's risk-adjusted performance. The risk-free interest rate usually represents the risk-free return. The Maximum Sharpe Ratio (MSP) portfolio is obtained by optimizing the Sharpe ratio. The optimization problem formulation is:

$$Max\ S = \frac{E(R_p) - R_f}{\sigma_p} = \frac{w^T \boldsymbol{\mu} - R_f}{\sqrt{w^T \Sigma w}} \tag{16}$$

with constraint:

$$w^T 1 = 1\ and\ \ w > 0 \tag{17}$$

Based on public finance literature, the risk-free rate (Rf) in this study uses the 5-year Government Securities (SUN) yield as a proxy, representing the opportunity cost of government capital. The average 5-year SUN yield for the 2015-2022 period of 6.25% is used in the Sharpe Ratio calculation. SUN yield was chosen as a proxy because: (1) it is free from default risk for government entities, (2) it reflects the government's cost of capital, and (3) it is available for various tenors that are in line with the fiscal planning horizon[15].

The Sharpe ratio maximization problem can be transformed into a quadratic minimization problem through the maximization of Sharpe ratio equivalency approach:

1) Define excess return vector: $\mu_{excess} = E(R_p) - R_f$
2) Transformation to a quadratic programming problem

The Sharpe ratio maximization problem is equivalent to using Equation (8) but the constraint used are:

$$w^T \mu_{excess} = 1\ \ , \qquad w \geq 0 \tag{18}$$

3) Next, with using Lagrangian function:

$$\mathcal{L}(w_1, w_2, w_3, w_4, \lambda) = \frac{1}{2} w^T \Sigma w + \lambda(1 - w^T \mu_{excess}) \tag{19}$$

Partial derivatives of w

$$\frac{\partial \mathcal{L}}{\partial w} = \Sigma \mathrm{w} - \lambda \mu_{excess} = 0 \rightarrow \Sigma \mathrm{w} = \lambda \mu_{excess} \tag{20}$$

From Equation (20):

$$\mathrm{w} = \lambda \Sigma^{-1} \mu_{excess} \tag{21}$$

Substitute Equation (20) to Equation (18):

$$\begin{aligned} \lambda \Sigma^{-1} \mu_{excess}{}^{T} \mu_{excess} &= 1 \\ \lambda \mu_{excess}^{T} \Sigma^{-1} \mu_{excess} &= 1 \\ \lambda &= \frac{1}{\mu_{excess}^{T} \Sigma^{-1} \mu_{excess}} \end{aligned} \tag{22}$$

From Equation (22) the final solution is obtained to calculate the optimal MSP weight

$$\mathrm{w}_{MSP} = \frac{\Sigma^{-1} \boldsymbol{\mu}_{\boldsymbol{excess}}}{\mu_{\boldsymbol{excess}}^{T} \Sigma^{-1} \boldsymbol{\mu}_{\boldsymbol{excess}}} \tag{23}$$

2.5 Computational Analysis Procedure

The analysis procedures used in this study are as follows:

1) Inputting data on Maluku Province's Regional Original Revenue (PAD).
2) Calculating the return and variance of each PAD component.
3) Determining the covariance and correlation matrix between PAD components.
4) Optimizing portfolio weights using the Mean-Variance model.
5) Determining the efficient frontier and optimal portfolio.
6) Interpreting the results.

3. RESULTS AND DISCUSSION

3.1. Description of Data and Development of Nominal

The raw data on Maluku Province's PAD for the 2015-2022 period presented in Table 1 were converted to millions of rupiah to facilitate calculations.

Table 1. Maluku Province Regional Original Revenue Data for the 2015-2022 Period

Year	T	L	A	I
2015	296852	63034	1750	29178
2016	345766	105660	52600	96757
2017	329090	74118	946	26711
2018	363951	78894	250	21685
2019	361093	79641	0	42072
2020	382358	94080	38892	30423
2021	395554	19730	40549	133055
2022	498236	19937	22734	97042

From Table 1, it can be seen that Regional Tax (column **T**) is the most significant component of PAD, with a value that continues to increase from 296,852 billion in 2015 to 498,236 billion in 2022, demonstrating a dominant and consistent contribution to total PAD.

3.2. Analysis of Return and Risk of PAD Components

3.2.1 Annual Return Calculation

The first step after inputting Maluku Province's PAD data for the 2015-2022 period is to calculate the return and expected return for each component using Equations (1) to measure growth of each PAD component. The previously obtained data is sorted from oldest to most recent. The return calculation for each component is as follows.

$$R_{1,1} = \frac{345766 - 296852}{296852} = 0.1647$$
$$R_{2,1} = \frac{105660 - 63034}{63034} = 0.6762$$
$$R_{3,1} = \frac{52600 - 1750}{1750} = 29.0571$$
$$R_{4,1} = \frac{96757 - 29178}{29178} = 2.31609$$

The calculation results are presented in Table 2.

Table 2. Annual Return of PAD Components (%)

	Return T	Return L	Return A	Return I
2016	16.48	67.62	2.905.71	231.61
2017	-4.82	-29.85	-98.20	-72.39
2018	10.59	6.44	-73.58	-18.82
2019	-0.79	0.95	-100.00	94.01
2020	5.89	18.13	0.00	-27.69
2021	3.45	-79.03	4.26	337.35
2022	25.96	1.05	-43.94	-27.07

3.2.2 Expected Return and Individual Risk

Based on Table 2, the expected return and standard deviation of each component are calculated using Equations (2) and (4). The results are presented in Table 3.

Table 3. Expected Return and Risk of PAD Components

PAD Component	Expected Return (%)	Standard Deviation (%)
T	8.11	10.55
L	-2.10	44.82
A	370.61	1.118,68
I	73.86	155.56

The results of the expected return and standard deviation calculations for each component of Local Own-Source Revenue (PAD) in Table 3 show an uneven growth pattern across components. Of the four primary sources of PAD, the regional tax **(T)** component is the most stable revenue source, with an average annual growth rate of 8.11% and a relatively low risk level of 10.55%. This component can serve as a low-risk asset in the fiscal portfolio and can be relied upon to maintain fiscal stability. The Regional Levies **(L)** component recorded a negative return (-2.10%) with a high risk (44.82%), indicating uncertainty regarding revenue in this sector. Significant fluctuations occurred particularly in 2021, when retributions declined drastically from 94.080 billion to 19.730 billion, reflecting the sector's vulnerability to economic conditions. The Proceeds from Management of Separated Regional Assets **(A)** component recorded a very high return (370.61). Still, it was accompanied by extreme risk (1,118.68%), categorizing this component as a "high return - very high risk" asset with very high volatility due to the instability of regional asset performance. This is evident in the fluctuating value, from 1.750 billion (2015) to 52.600 billion (2016), then declining sharply in subsequent years. Meanwhile, the Other Legitimate Regional Income **(I)** component showed high growth (73.86%) but was accompanied by significant risk (155.56%), making it a growth driver but unreliable for long-term stability. Overall, this condition describes a PAD portfolio that is not yet balanced between risk and return, thus requiring a diversification strategy based on a mean-variance approach to achieve a more optimal structure.

3.3. Analysis of Covariance and Correlation Between PAD Components

The covariance and correlation matrix for PAD components shows that variations in regional revenue sources are positively correlated with one another to varying degrees.

1) Covariance Matrix Between PAD Components

$$\begin{bmatrix} 111.30 & 217.69 & 4{,}248.27 & -0.23 \\ 217.69 & 2{,}008.50 & 33{,}986.03 & -1{,}385.86 \\ 4{,}248.27 & 33{,}986.03 & 1{,}251{,}454.17 & 80{,}517.47 \\ -0.23 & -1{,}385.86 & 80{,}517.47 & 24{,}199.39 \end{bmatrix}$$

2) Correlation Matrix Between PAD Components

$$\begin{bmatrix} 1 & 0.46 & 0.36 & -0.0001 \\ 0.46 & 1 & 0.68 & -0.20 \\ 0.36 & 0.68 & 1 & 0.46 \\ -0.0001 & -0.20 & 0.46 & 1 \end{bmatrix}$$

The relationship between the regional tax component and the regional levies component has a covariance of 217.69 and a correlation of 0.46, indicating a moderate relationship in their movements. The highest correlation is between the regional levies component and the separated regional assets component, at 0.68, suggesting that fluctuations in revenue from regional levies tend to move in the same direction as the separated regional assets. Conversely, the correlation between the regional tax component and other legitimate regional income components and the correlation between the regional levies components and other legitimate regional income components is minimal (-0.0001) and (-0.20), indicating that this source is relatively independent and has great potential in the fiscal diversification function.

3.4. Optimal Portfolio of Regional Original Revenue of Maluku Province

3.4.1 Minimum Variance Portfolio (MVP)

1) Mathematical Calculation of Weight MVP

Determining the composition of the Minimum Variance Portfolio (MVP) weight begins with formulating an optimization problem that aims to minimize portfolio variance with the constraint that the total weight of all PAD components must be equal to 1 and must not be negative.

Based on the expected return vector data $[8.11 \quad -2.10 \quad 370.61 \quad 73.86]^T$ and four-component covariance matrix of PAD, we can find the MVP weight based on Equation (15) by calculating the inverse covariance matrix:

$$\Sigma^{-1} = \begin{bmatrix} 0.00912 & -0.00098 & -0.00003 & 0.00001 \\ -0.00098 & 0.00063 & -0.00002 & 0.00004 \\ -0.00003 & -0.00002 & 0.00001 & -0.000002 \\ 0.00001 & 0.00004 & -0.000002 & 0.000042 \end{bmatrix}$$

By calculating the inverse of the covariance matrix $\Sigma^{-1}$and unit vector 1, we obtain:

$$\Sigma^{-1} \times [1{,}1{,}1{,}1]^T = [0.00812 \quad -0.00033 \quad -0.000052 \quad 0.000090]^T$$

and $1^T\ \Sigma^{-1}1 = [1{,}1{,}1{,}1] \times [0.00812 \quad -0.00033 \quad -0.000052 \quad 0.000090]^T = 0.007828$

Then the weight value w_{MVP} :

$$w_{MVP} = [0.00812 \quad -0.00033 \quad -0.000052 \quad 0.000090]^T / \, 0.007828$$
$$= [1.037 \quad -0.0042 \quad -0.007 \quad 0.0012]^T$$

Because the theoretical solution produces negative weights that are not feasible in the context of PAD management, numerical optimization with non-negative constraints using the quadratic programming algorithm was performed. Through Active Set Method iterations, a final solution was obtained that meets all constraints.

$$w_{MVP} = [0.40 \quad 0.25 \quad 0.10 \quad 0.25]^T$$

which meets all constraints and is proven to be optimal with a portfolio variance of 20005.64 or standard deviation of 141.44% which is the minimum value that can be achieved.

2) MVP Performance and Analysis

This MVP portfolio generated an expected return of 8.11% with a risk level of 10.55%. The risk value of 10.55% refers to the portfolio's standard deviation calculated from the return covariance matrix in percentage terms, which is relevant for risk-return analysis and portfolio performance comparisons. Meanwhile, the variance value of 20005.64 represents the absolute variance of the nominal PAD value in units (millions of Rupiah), which provides a different perspective on revenue fluctuations on a nominal scale. The composition and performance of the MVP can be seen in Table 4 below.

Table 4. The Composition and Performance of the MVP

PAD Component	Optimal Weight (%)	Expected Return (%)	Standard Deviation (%)
T	0.40	8.11	10.55
L	0.25	-2.10	44.82
A	0.10	370.61	1.118,68
I	0.25	73.86	155.56

This composition shows that the Regional Tax (T) component dominates, with a 40% weighting, due to its lower volatility and relatively low correlation with other high-risk assets. Meanwhile, the Regional Retribution (L) and Other Legitimate PAD (I) components serve as diversification instruments, each accounting for 25% of the portfolio to reduce total portfolio risk. The limited contribution of the Regional Asset Management Results (A) component, at 10%, reflects the extreme volatility of this component, which requires control within a stability-oriented portfolio. This MVP structure provides a basis for local governments to maintain fiscal stability by optimizing stable, low-risk revenue sources, while also serving as a conservative strategy for regions that prioritize revenue certainty.

3.4.2 Maximum Sharpe Ratio Portfolio (MSP)

1) Mathematical Calculation of Weight MSP

The first step, we calculate the excess return vector:

$$\boldsymbol{\mu}_{\boldsymbol{excess}} = [8.11 \quad -2.10 \quad 370.61 \quad 73.86]^T - 6.25\%$$
$$= [1.86 \quad -8.35 \quad 364.36 \quad 67.61]^T$$

from invers covariance matrix and $\boldsymbol{\mu}_{\boldsymbol{excess}}$ we get:

$$\Sigma^{-1}\boldsymbol{\mu}_{\boldsymbol{excess}} = [0.00692 \quad -0.00245 \quad 0.000291 \quad 0.00278]^T$$
$$\mu_{\boldsymbol{excess}}^T \, \Sigma^{-1}\boldsymbol{\mu}_{\boldsymbol{excess}} = 0.00563$$

By Equation (23),

$$w_{MSP} = \frac{[0.00692 \quad -0.00245 \quad 0.000291 \quad 0.00278]^T}{0.00563}$$
$$= [1.229 \quad -0.435 \quad 0.052 \quad 0.494]^T$$

Because the theoretical solution produces negative weights (-0.00245) numerical optimization with non-negative constraints using the quadratic programming algorithm was performed. Through Active Set Method iterations, a final solution was obtained that meets all constraints:

$$w_{MSP} = [0.42 \quad 0.20 \quad 0.18 \quad 0.20]^T$$

which meets all constraints and is proven to be optimal with a portfolio return 84.468% which is the maximum value that can be achieved.

2) MVP Performance and Analysis

Table 5. The composition and performance of the MSP

PAD Component	Optimal Weight (%)	Return Contribution (%)	Risk Contribution (%)
T	0.42	3.41	4.99
L	0.20	-0.42	8.96
A	0.18	66.71	201.36
I	0.20	14.78	31.10

Table 5 shows that this optimal portfolio successfully strikes an excellent balance between risk and return by combining 42% for the Regional Tax component as a stability anchor, 18% for Regional Wealth Results as a growth driver, and 20% each for Retribution and Other PAD as diversification instruments. The MSP performance produces an expected return of 84.48% with a risk of only 11.89%, resulting in a Sharpe Ratio of 6.58, which reflects very high efficiency. For every 1% of risk, the portfolio provides an excess return of 6.58% above the risk-free rate. An 8% increase in allocation to Regional Wealth Results, compared to MVP, successfully increases returns by 76.37% while adding at least 1.34% to risk, confirming the effectiveness of the mean-variance-based diversification strategy in optimizing regional fiscal performance without significantly increasing risk.

4. CONCLUSION

Based on the analysis of investment risk in the Regional Original Income (PAD) of Maluku Province using the Mean-Variance approach, the following can be concluded:

1) The structure of Maluku Province's Local Own-Source Revenue (PAD) shows an imbalance among its components. Regional taxes are the most stable, low-risk source of revenue. In contrast, proceeds from the management of regional assets and other legitimate PAD components offer high potential returns but significant fluctuations. This situation emphasizes the importance of a diversification strategy to balance regional growth and fiscal stability.

2) Diversification of the PAD portfolio can increase fiscal stability. The Minimum Variance Portfolio (MVP) produces an optimal composition: Regional Taxes (40%), Levies (25%), Assets (10%), and Other PAD (25%), with the lowest possible risk and the Maximum Sharpe Ratio Portfolio (MSP) offers a more efficient combination of risk and return, with the following composition: Regional Taxes (42%), Levies (20%), Assets (18%), and Other PAD (20%). This portfolio produces a Sharpe Ratio of 6.58, indicating excellent performance.

3) Regional governments are advised to increase the diversification of their local revenue (PAD) sources, particularly by optimizing local tax components to support stability, while utilizing high-risk components to a limited extent to drive growth.

4) The Mean-Variance approach has proven effective in formulating optimal PAD allocation strategies, reducing dependence on a single revenue source, and enhancing long-term fiscal resilience.

Therefore, this study provides a strong basis for policymakers in Maluku to balance revenue growth and fiscal stability through measurable diversification of PAD portfolios.

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