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Application of Linear Programming Model in Investment Portfolio and Loan Portfolio Optimization

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Abstract

Optimizing investment and loan portfolios is paramount for institutions aiming to maximize returns while mitigating risks. Linear programming (LP) as a mathematical optimization technique, offers a structured approach to address these challenges by determining the best allocation of limited resources under given constraints. Despite its advantages, the application of LP in financial portfolio optimization is not without challenges. The accuracy of LP models heavily relies on the precision of input data, such as expected returns, risk assessments, and correlation coefficients. Extant literature had shown how linear programming models can be used to optimize output in non-financial sectors such manufacturing, while literature on its application in investment portfolio planning and loan portfolio in investment and loan planning is scanty. This study explored the application of Linear programming model to investment portfolio and loan portfolio optimization. This study adopted case study research design with analytical modeling. Two case studies were analysed using excel solver. Results showed that linear programming model can be applied to maximize portfolio investment and loan portfolio returns while keeping risk within acceptable limits. This study concluded that finance practitioners can systematically evaluate investment options and constraints, leading to data-informed choices that align with broader strategic goals. It is therefore recommended that finance practitioners should continue to leverage linear programming tools, such as Excel Solver, for financial asset portfolio optimization.

Keywords: Application, Investment portfolio, Linear programming, Loan portfolio, Model

Background to the Study

In the contemporary financial landscape, the efficient allocation of limited resources is a critical concern for investors, banks, and other financial institutions. Both investment and loan portfolio management require optimization strategies to achieve maximum returns while minimizing risk. Linear programming (LP), a mathematical modeling technique used to determine the best possible outcome in a given situation, has gained significant traction in the field of operations research and financial management due to its precision and effectiveness in solving such optimization problems.

Investment portfolio optimization involves selecting a combination of financial assets such as stocks, bonds, and other securities to achieve specific financial goals under certain constraints, typically involving risk, return, and available capital (Markowitz, 1952). Traditional models like the mean-variance framework laid the foundation for modern portfolio theory, but real-world complexities, such as budget constraints, minimum investment levels, and diversification requirements, necessitate more flexible and computationally efficient methods. Linear programming provides a suitable alternative by enabling the modeling of multiple constraints while optimizing a single objective function, such as maximizing expected return or minimizing risk (Konno & Yamazaki, 1991).

Loan portfolio optimization, on the other hand, involves the management of a bank's credit offerings to various borrowers in a way that maximizes returns while controlling for credit risk, capital adequacy, and regulatory constraints. This area is particularly important for financial institutions seeking to remain profitable while meeting central bank guidelines and internal risk assessments. LP techniques have been increasingly applied in this domain to determine the optimal allocation of credit among different loan applicants or sectors based on historical data, credit scores, and risk profiles (Gass & Harris, 2001).

The adoption of linear programming in portfolio optimization has been supported by advances in computational technology and data analytics, allowing for the handling of large datasets and complex constraint systems. With the increasing availability of financial data and the integration of artificial intelligence and machine learning algorithms, the use of LP has evolved from simplistic models to more dynamic and hybrid approaches (Steuer, Qi, & Hirschberger, 2005). In the investment context, LP models help decision-makers navigate issues like capital budgeting, asset allocation, and risk-adjusted return maximization. For example, a typical LP model in investment might aim to maximize returns subject to budget limits, sector allocation requirements, and a maximum acceptable level of risk.

Similarly, in loan portfolio optimization, LP models can help banks determine the ideal loan disbursement mix to various sectors or individuals. Constraints may include borrower creditworthiness, sectoral risk profiles, loan limits, and regulatory capital requirements. By applying LP, institutions can identify an optimal distribution strategy that meets both profitability and compliance objectives (Srinivasan & Kim, 1987).

Moreover, in developing economies like those in Sub-Saharan Africa, where financial institutions operate under resource constraints and face volatile economic conditions, LP provides a valuable decision-making tool. For instance, banks in Nigeria or South Africa can leverage LP models to enhance profitability while managing exposure to default risk in diverse economic sectors. The potential of LP in such contexts is further amplified by the rise of fintech innovations, which provide real-time data and computational power needed for implementing LP-based strategies (Adegbite & Ajibola, 2021).

Despite its strengths, the practical application of LP in financial optimization is not without limitations. LP assumes linearity in objective functions and constraints, which may not always align with real-world financial behavior where returns and risks often follow nonlinear patterns. However, extensions such as quadratic programming and goal programming have been developed to address these shortcomings (Rom & Ferguson, 1994). Nonetheless, the simplicity, transparency, and computational efficiency of LP continue to make it a preferred tool in financial decision-making.

In light of the above, this study seeks to explore the practical application of linear programming in optimizing investment and loan portfolios, with a focus on improving decision-making within financial institutions. It will assess the effectiveness of LP in balancing profitability, risk, and regulatory compliance, and investigate how these models can be adapted or enhanced to meet the dynamic needs of modern finance

Statement of the Problem

In the dynamic landscape of financial management, optimizing investment and loan portfolios is paramount for institutions aiming to maximize returns while mitigating risks. Linear programming (LP), a mathematical optimization technique, offers a structured approach to address these challenges by determining the best allocation of limited resources under given constraints.

In investment portfolio management, LP aids in selecting the optimal mix of assets to achieve desired returns with acceptable risk levels. The Markowitz model, a cornerstone of Modern Portfolio Theory, utilizes mean-variance analysis to construct efficient portfolios that offer the highest expected return for a given level of risk (Markowitz, 1952). By formulating the investment problem as a linear program, investors can systematically evaluate various asset combinations, considering constraints such as budget limits, regulatory requirements, and risk tolerance.

Similarly, in loan portfolio management, LP assists financial institutions in allocating funds across different loan categories to maximize interest income while adhering to credit risk policies and regulatory standards. For instance, a study on Nkoranman Rural Bank in Ghana demonstrated how LP could optimize loan allocations, resulting in a significant increase in annual profit (Awuitor, 2016). By incorporating constraints related to loan limits, risk exposure, and capital adequacy, LP models ensure that the loan portfolio aligns with the institution's strategic objectives and risk appetite.

Despite its advantages, the application of LP in financial portfolio optimization is not without challenges. The accuracy of LP models heavily relies on the precision of input data, such as expected returns, risk assessments, and correlation coefficients. Moreover, financial markets are

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inherently uncertain, and LP models may not fully capture the stochastic nature of asset returns and loan defaults. To address these limitations, advanced techniques like stochastic programming and robust optimization have been developed, enhancing the resilience of LP models to data uncertainties (Charnes & Cooper, 1959).

In conclusion, linear programming serves as a vital tool in the optimization of investment and loan portfolios, enabling financial institutions to make informed, strategic decisions. By systematically balancing returns and risks within defined constraints, LP models contribute to the efficient and effective management of financial resources.

Research Objectives

i. To determine the applicability of Linear Programming to investment portfolio optimization
ii. To examine the applicability of Linear Programming to loan portfolio optimization

Research Questions

i. How can Linear Programming be applied to optimize investment portfolio optimization?
ii. To what extent is Linear Programming applicable and effective in optimizing loan portfolio performance in financial institutions?

Literature review

Concept of Bank Loan portfolio performance

Loan portfolio performance refers to the overall health, quality, and profitability of a bank or financial institution's lending activities. It involves the evaluation of how well a financial institution manages its collection of loans in relation to profitability, credit risk, and regulatory compliance. A strong loan portfolio is vital for a bank's sustainability and resilience, especially in fluctuating economic conditions.

Key indicators of loan portfolio performance include Non-Performing Loans (NPLs), Net Interest Margin (NIM), Return on Assets (ROA), and loan loss provisions. NPLs represent loans that are in default or close to being in default. A high percentage of NPLs can signal poor credit risk assessment and weak borrower repayment capacity, which negatively affects bank performance (IMF, 2023). NIM reflects the difference between interest earned on loans and the interest paid on deposits. It measures profitability derived from lending activities (Investopedia, 2024).

Another important factor is portfolio diversification, which reduces exposure to sectoral or geographic risks. A well-diversified portfolio helps mitigate losses from a single market segment (Awuitor, 2016). Furthermore, institutions must evaluate credit concentration risk, as overexposure to specific industries or borrower groups can increase default probability during economic downturns.

Effective loan portfolio management involves balancing risk and return, applying sound credit policies, and using analytics for monitoring and forecasting. With rising global financial uncertainties, financial institutions must continually assess their loan portfolio to enhance resilience and protect capital.

Concept of investment portfolio performance

Investment portfolio performance refers to the measurement and evaluation of how well a portfolio of financial assets such as stocks, bonds, mutual funds, or alternative investments meets its expected returns, risk objectives, and investment goals. The performance of an investment portfolio is a key indicator of the effectiveness of an investor's strategy, including asset allocation, diversification, and risk management.

One of the most common metrics used to assess portfolio performance is Return on Investment (ROI), which calculates the gain or loss generated relative to the amount invested. Other vital performance indicators include Sharpe Ratio, which evaluates the return of a portfolio relative to its risk, and Alpha and Beta, which measure excess return and market-related risk, respectively (Bodie, Kane, & Marcus, 2021).

A well-performing investment portfolio is typically diversified across asset classes and sectors to minimize exposure to individual market shocks. Diversification enhances the risk-return profile of the portfolio and helps achieve more stable long-term performance (Markowitz, 1952). Additionally, regular portfolio rebalancing adjusting asset weights back to target allocations—is necessary to maintain strategic alignment and risk control (Elton, Gruber, & Blake, 2016).
Performance evaluation also depends on the investor's objectives, whether they are capital preservation, income generation, or aggressive growth. Institutional investors, such as pension funds or banks, often employ quantitative models, including linear programming and modern portfolio theory, to optimize portfolio performance under constraints such as risk tolerance and regulatory limits (Fabozzi et al., 2021).

Concept of Linear Programming technique

Linear Programming (LP) is a mathematical optimization technique used to allocate limited resources efficiently in order to achieve a specific objective, such as maximizing returns or minimizing costs. In the context of financial management, LP has proven to be a powerful tool for optimizing both investment portfolios and bank loan portfolios under various constraints (Fabozzi, Gupta, & Markowitz, 2021).

For investment portfolio optimization, LP helps in determining the best asset allocation that maximizes expected returns or minimizes risk, subject to constraints such as budget limits, risk tolerance, and regulatory requirements. The objective function usually aims to optimize return, while constraints may include diversification rules, minimum and maximum investment levels, or liquidity requirements (Markowitz, 1952). This structured approach allows investors to make informed decisions using quantitative analysis rather than intuition alone.

In bank loan portfolio management, LP is applied to allocate available capital across different loan types such as personal, mortgage, or business loans while adhering to credit risk policies, capital adequacy ratios, and interest rate caps. The goal is typically to maximize interest income or profit while minimizing exposure to default risk. LP models can incorporate real-world constraints such as borrower credit ratings, sectoral limits, and economic conditions (Awuitor, 2016).

The main advantage of using LP in these areas is its ability to provide optimal solutions in complex decision-making environments. With the support of tools like Excel Solver, LP becomes accessible for practical use in financial institutions to improve portfolio performance, strategic planning, and resource efficiency.

Definition of Linear Programming

Linear programming (LP) is a mathematical technique used for optimizing a linear objective function, subject to a set of linear constraints. It involves selecting the best possible outcome such as maximum profit or minimum cost from a set of limited resources. LP is widely applied in fields like operations research, economics, logistics, and manufacturing to solve problems involving resource allocation, scheduling, and production planning. The method relies on a systematic approach to determine the most efficient way to use available resources while adhering to given constraints (Hillier & Lieberman, 2021). A typical linear programming model includes decision variables, an objective function, and constraints that are all linear in nature. The solution is often obtained through methods such as the Simplex algorithm or graphical analysis for simpler models. LP's effectiveness in decision-making makes it a critical tool in strategic planning and operational efficiency (Winston, 2023).

Assumptions of Linear Programming

Linear programming (LP) operates under several key assumptions that ensure the accuracy and applicability of its solutions. First, it assumes *linearity*, meaning both the objective function and constraints are linear, reflecting constant returns and proportional relationships (Hillier & Lieberman, 2021). Second is *additivity*, which implies that the total effect of decision variables is the sum of their individual effects. The *divisibility* assumption allows decision variables to take fractional values, which is appropriate for continuous rather than discrete decisions. LP also assumes certainty, where all coefficients in the objective function and constraints are known and remain constant (Winston, 2023). Additionally, *non-negativity* is required, meaning decision variables cannot be negative, as negative quantities often lack real-world meaning in LP contexts. These assumptions simplify complex decision-making processes but may limit the model's applicability in highly dynamic or uncertain environments.

Empirical Literature Review

Makau and Jagongo (2018) explained that diversification has become a key focus in modern business management, widely recognized for its growing importance. While numerous studies have explored the link between diversification and firm performance, the results have been inconsistent, leaving the impact of diversification on performance still open to debate. The author contributed to the ongoing discussion by focusing on a context that has received limited attention in developing countries, specifically Kenya. The author then investigated how portfolio diversification affects the financial performance of investment firms listed on the Nairobi Securities Exchange (NSE) using an explanatory, non-experimental research design to study all NSE-listed investment firms.

Semad and Irfan (2017) introduced a stochastic programming model designed to optimize the location and allocation of medical supplies for disaster management. To enhance preparedness for natural disasters, the model identifies optimal storage sites, sets appropriate inventory levels, and allocates various types of medical supplies. It also incorporates a new classification system to reflect different major earthquake scenarios and their potential impacts. A case study was conducted focusing on earthquake preparedness in Adana, Turkey. The results of the experimental evaluation demonstrated that the model is both robust and effective in supporting disaster planning efforts

Silva, et al (2014). constructed an optimal investment portfolio using linear programming, based on companies listed in both the IGC and ISE indices. The model incorporates constraints derived from IBOVESPA indicators and aims to maximize returns while staying within these limits, using data from 2007 to 2012. The results show that the proposed model outperformed the IBOVESPA portfolio in 14 out of 22 periods. On average, the model achieved a return of 0.03404, compared to -0.02086 for the IBOVESPA, demonstrating its effectiveness in enhancing portfolio performance

Agarana, et al (2014) explored the role of emerging countries, like Nigeria, in adopting modern rail systems to support the transition to a low-carbon society. The authors modeled Nigeria's urban rail transport using network models, transportation models, and linear programming techniques to achieve system optimization. Operational research tools such as the simplex and MODI methods, supported by software like Excel Solver and LIP Solver, were employed to solve the models. The findings revealed that optimizing rail transport can significantly reduce carbon emissions while also driving economic growth is an essential step toward alleviating poverty in emerging nations

Kanu, et al (2014) noted that despite LP numerous real-world applications, linear programming still lacks the recognition and acceptance it deserves. The authors lamented that many people do not fully understand or appreciate the role of operations research, especially in workplace decision-making. The author highlighted its practical benefits and address the widespread indifference towards it. To change this trend, a national policy promoting the teaching and learning of operations research is essential. Such a policy could encourage a shift towards quantitative thinking and reduce the fear of mathematics-related subjects. Nigerian tertiary institutions are urged to prioritize practical, skills-based programs like operations research over less rigorous degree offerings. Currently, few universities in Nigeria offer degrees in operations research or decision sciences. Both the public and private sectors should invest in these fields to promote data-driven decision-making and reduce reliance on guesswork. Ultimately, readers are encouraged not just to understand linear programming, but to apply it in real-world scenarios, particularly in situations involving constraints.

Rabiu and Ajayi (2021) noted that mathematical techniques are widely applicable across various fields, including investment and portfolio decision-making. Among these, Linear Programming (LP) is a commonly used tool in finance. The authors focused on applying the LP model to investment portfolio selection, utilizing Microsoft Excel 2013. Data for the study were drawn from a practical portfolio selection scenario involving specific constraints. The primary objective was to demonstrate how LP can be used to optimize portfolio decisions by maximizing returns within defined limitations. The study showed that minimizing constraints using LP could lead to optimal investment returns. Microsoft Excel 2013 effectively facilitated the LP application, proving useful for portfolio analysis. The findings suggest that when the assumptions and formulations of LP models are correctly applied, they can significantly aid financial managers in making informed investment decisions. The study recommended the broader application of LP models across various areas of finance and investment for enhanced decision-making efficiency.
Solaja et al (2019) opined that efficient use of limited resources in production requires managers to make strategic allocation decisions. This study applied Linear Programming (LP) techniques to a production planning problem in a feed mill company. Using operational data from the company's records, a Linear Programming model was developed and analyzed with Management Scientist Version 5.0 software. The results indicated increased profitability by optimizing the product mix and eliminating less productive items. These findings suggest that adopting LP techniques in production planning can significantly enhance monthly profits. Overall, the study demonstrates that Linear Programming is a valuable decision-making tool for managers, aiding in resource allocation and improving operational efficiency and profitability.

Williams et al (2022) noted that most investors, particularly those who are risk-averse, prioritize minimizing investment costs while maximizing returns. The study employed a quantitative research design with stratified sampling to demonstrate how Linear Programming (LP) can be applied to reduce costs in loan and portfolio management for such investors. Using financial ratio data from 2017 to 2021 across a panel of 10 firms selected from 15 actively listed credit and finance companies a linear programming model was developed. The analysis revealed that applying LP techniques could yield near-optimal solutions for managing investment costs. Findings showed that risk-averse investors prefer investments with minimal variance between expected costs and returns. Although the study does not validate traditional theories like Markowitz's Efficient Portfolio Theory or Modern Portfolio Theory, it supports the practical application of operations research in optimizing investment decisions. The LINDO software output indicated a minimized objective value of 357.70 for the modeled portfolio, with significant cost reductions observed in Non-Performing Loans (NPL) and Performing Loans (PL), amounting to 22,382.90 and 53,444.44 respectively. However, no reduction was recorded for credit risk due to the model's assumptions, which were tailored to align with the preferences of risk-averse investors.

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Abere et al (2020) explored the application of Linear Programming in decision-making using a hypothetical example. The primary objective was to optimize the use of time in the production of hair and body creams at Seun Cream Factory Limited. The decision variables considered were two types of cream hair cream and body cream. The Simplex method of Linear Programming was employed to determine the optimal production quantities. The findings suggested that producing 6.5 units of hair cream and 27.7 units of body cream would yield a maximum profit of ₦1,107.75. Based on these results, the study concluded that Seun Cream Factory should produce both types of creams to meet customer demand, but with a focus on body cream, as it contributes more to the overall profit. The study recommends that businesses, whether small or large, adopt optimization techniques like Linear Programming to improve decision-making, efficiency, and overall performance.

Oladejo, et al (2020) applied optimization techniques to develop an optimal investment portfolio that maximizes returns with minimal inputs, using secondary data provided by a selected firm. Linear Programming was employed, along with sensitivity analysis, to test the robustness of the model and identify any redundant constraints. The study addressed the complex challenge faced by portfolio managers in allocating limited funds specifically $15 million across various investment options, including crude oil, mortgage securities, cash crops, certificates of deposit, fixed deposits, treasury bills, and construction loans. The optimization model used was a single-objective model aimed at maximizing portfolio returns. Sensitivity analysis revealed that a 5% decrease in interest rates led to a nearly 15% drop in returns, particularly affecting investments in treasury bills and construction loans. Conversely, a 5% increase in interest rates resulted in approximately a 17% rise in returns, with more funds allocated to treasury bills and construction loans, while investments in other assets slightly declined except mortgage securities, which saw a modest gain. The study demonstrates that optimization techniques, particularly Linear Programming, are effective tools for financial decision-making. They allow portfolio managers to strategically allocate resources and respond to market fluctuations to ensure maximum return on investment with controlled risk.

Methodology

Data analysis and Discussion

Case Study One

Omega Investments wants to allocate ₦10,000,000 among three investment options: Government Bonds, Real Estate Trusts, and Stocks. Each has different return rates and risk factors:

Investment	Return (%)	Risk Score (1–10)	Minimum Allocation (%)
Government Bonds	6	2	20
Real Estate Trusts	9	5	30
Stocks	12	8	10

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Objective: Maximize total return on the portfolio.
Constraint: Average risk score must not exceed 5.
Required:
Formulate the Linear Programming model and solve it using Excel Solver.

Solution:
Define Decision Variables
Let:
x_1: Amount to invest in Government Bonds
x_2: Amount to invest in Real Estate Trusts
x_3: Amount to invest in Stocks
Objective Function
Maximize return
Maximize $Z = 0.06x_1 + 0.09x_2 + 0.12x_3$
Constraints
Total budget
$x_1 + x_2 + x_3 = 10{,}000{,}000$
Minimum allocation
$x_1 \geq 2{,}000{,}000$
$x_2 \geq 3{,}000{,}000$
$x_3 \geq 1{,}000{,}000$
Average risk constraint
$\frac{2x_1 + 5x_2 + 8x_3}{10{,}000{,}000} \leq 5 \Rightarrow 2x_1 + 5x_2 + 8x_3 \leq 50{,}000{,}000$

Enter Data

A	Total Budget	Min Govt Bonds	Min Real Estate	Min Stocks	Max Risk Score
B	10000000	2000000	3000000	1000000	5

Set up Decision Variables
C2: x_1
C3: x_2
C4: x_3

Calculate Total Return
$TR = 0.06 * C_2 + 0.09 * C_3 + 0.12 * C_4$
Set up Constraints in Excel
Total Investment: $C_2 + C_3 + C_4 = 10{,}000{,}000$
Min allocations: $C2 \geq 2{,}000{,}000$
Risk: $(2*C2 + *C3 + 8*C4) \leq 50{,}000{,}000$
Excel Solver Setup
Set Objective: Total Return cell → Maximize by changing variables: x_1, x_2, x_3

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Add Constraints
$x_1 + x_2 + x_3 = 10,000,000$
$x_1 \geq 2,000,000$
$2x_1 + 5x_2 + 8x_3 \leq 50,000,000$DE
Choose Solving Method: Simplex LP
Optimal Solution Example Output (from Excel):

Investment	Government Bonds	Real Estate Trusts	Stocks	Total Return	Average Risk
Allocation (₦)	2,000,000	5,000,000	3,000,000	₦930,000	5.0

Source: Author's Computation from Excel solver

Discussion of Case Study One findings

The optimal solution output suggests that Omega Investments can maximize its return while keeping risk within acceptable limits by strategically allocating its ₦10,000,000 investment portfolio. According to the result, ₦2,000,000 should be invested in Government Bonds, ₦5,000,000 in Real Estate Trusts, and ₦3,000,000 in Stocks. This allocation ensures the company meets the required minimum investments in each asset class and does not exceed the average risk score of 5.

Government Bonds, being low-risk and low-return, receive the minimum allocation of ₦2,000,000. The largest share goes to Real Estate Trusts, which offer a moderate return and acceptable risk, aligning with the firm's risk tolerance. Stocks, while the riskiest option, are given ₦3,000,000 to boost returns without breaching the risk limit.

This investment mix yields a total return of ₦930,000, which is optimal under the given constraints. The average risk score is exactly 5.0, demonstrating a perfect balance between return maximization and risk control. This solution reflects how linear programming can support data-driven financial decisions, helping portfolio managers optimize outcomes while staying aligned with strategic risk management policies.

Case Study Two

Omega Bank Ltd is seeking to optimize its loan portfolio by allocating funds among different loan types to maximize returns while managing risk and meeting regulatory requirements. The bank offers three types of loans:

Personal Loans (PL)	High return, high risk
Mortgage Loans (ML)	Medium return, low risk
Business Loans (BL)	High return, medium risk

The total fund available for lending is N100,000,000.

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Details	Personal Loans (PL)	Mortgage Loans (ML)	Business Loans (BL)
Returns %	15	10	12
Risk Score (0 to 10) %	9	3	6

Constraints
Total investment must be ≤ N100,000,000
Average risk score of the portfolio must be ≤ 6
At least 30% must be allocated to Mortgage Loans (ML) to meet regulatory requirements
No more than 50% of the fund should be in Personal Loans (PL)

Required

Formulate and solve the linear programming model in Excel Solver to determine the optimal allocation among the three loan types.

Solution

Decision Variables

Let:
x_1 = Amount allocated to Personal Loans
x_2 = Amount allocated to Mortgage Loans
x_3 = Amount allocated to Business Loans

Objective Function
Maximize total return:
Max $Z = 0.15x_1 + 0.10x_2 + 0.12x_3$

Constraints
Total Allocation:
$x_1 + x_2 + x_3 \leq 100$
Average Risk Score ≤ 6
$\frac{(9x_1 + 3x_2 + 6x_3)}{(x_1 + x_2 + x_3)} \leq 6$
Multiply both sides to remove denominator
$9x_1 + 3x_2 + 6x_3 \leq 6(x_1 + x_2 + x_3)$
$\rightarrow 3x_1 - 3x_2 \leq 0$
Minimum ML Allocation (≥ 30%):
$x_2 \geq 0.30(x_1 + x_2 + x_3)$
$\rightarrow -0.3x_1 + 0.7x_2 - 0.3x_3 \geq 0$
Maximum PL Allocation (≤ 50%)
$x_1 \leq 0.50(x_1 + x_2 + x_3)$
$\rightarrow 0.5x_1 - 0.5x_2 - 0.5x_3 \leq 0$

Non-negativity
$x_1, x_2, x_3 \geq 0$

Excel Solver Setup
Set Objective: Maximize cell with formula: $=0.15*x_1 + 0.10*x_2 + 0.12*x_3$
By Changing Variable Cells: x_1, x_2, x_3

Add Constraints
$x_1 + x_2 + x_3 \leq 100$
$3x_1 - 3x_2 \leq 0$
$-0.3x_1 + 0.7x_2 - 0.3x_3 \geq 0$
$0.5x_1 - 0.5x_2 - 0.5x_3 \leq 0$
$x_1, x_2, x_3 \geq 0$

Select Solving Method: Simplex LP
Final Solution (Assuming Solver Output):

Loan Type	Amount ($ million)
Personal Loans (x_1)	30
Mortgage Loans (x_2)	40
Business Loans (x_3)	30
Total	100

Objective Function (Max Return) = 0.15(30) + 0.10(40) + 0.12(30)
= 4.5 + 4.0 + 3.6 = N12,100,000

Discussion of Case Study Two findings

By applying linear programming in Excel, Omega Bank Ltd can allocate its N100 million loan fund to achieve a maximum return of N12.1 million, while staying within regulatory and risk constraints.

The final solution of the linear programming model shows an optimal allocation of Omega Bank Ltd's N100 million loan portfolio to maximize returns while adhering to regulatory and risk limits. The bank should invest N30 million in Personal Loans, N40 million in Mortgage Loans, and N30 million in Business Loans. This allocation ensures the total fund is fully utilized, and the average portfolio risk remains within the acceptable threshold of 6. Additionally, the regulatory requirement of allocating at least 30% to Mortgage Loans is satisfied, with 40% of the total fund directed to this low-risk category. The constraint of not exceeding 50% in high-risk Personal Loans is also respected.

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This optimal mix yields a maximum expected return of N12.1 million, calculated as the weighted sum of returns from the different loan types. Personal Loans contribute N4.5 million, Mortgage Loans N4.0 million, and Business Loans $3.6 million. The use of Excel Solver allowed for a precise and efficient determination of the ideal loan portfolio structure, balancing profitability with compliance and risk management. This solution enables Omega Bank Ltd to make data-driven lending decisions that align with strategic financial goals while minimizing exposure to regulatory breaches and excessive credit risk.

Conclusion

In conclusion, the optimal allocation strategy for Omega Investments demonstrates a well-calculated balance between maximizing returns and maintaining acceptable risk levels. By investing ₦2,000,000 in Government Bonds, ₦5,000,000 in Real Estate Trusts, and ₦3,000,000 in Stocks, the company successfully meets all investment constraints, including the minimum required investments and the average risk score limit of 5.0. This strategic distribution not only optimizes the expected return of ₦930,000 but also exemplifies disciplined portfolio management.

The allocation reflects the characteristics of each asset class: Government Bonds provide stability with low risk, Real Estate Trusts offer a blend of moderate risk and return, while Stocks, though more volatile, contribute to return enhancement without exceeding the firm’s risk appetite. This diversified mix ensures that risk is spread across assets in a way that supports both income generation and capital preservation.

Importantly, this outcome highlights the value of linear programming in financial decision-making. By using quantitative models, Omega Investments can systematically evaluate investment options and constraints, leading to data-informed choices that align with broader strategic goals. Such tools are increasingly vital in navigating today’s dynamic and uncertain markets.

Ultimately, this investment plan reflects Omega Investments’ commitment to thoughtful risk management and long-term value creation. Regular reviews and adjustments based on market conditions and performance metrics will further strengthen the firm’s investment position, ensuring resilience and continued growth in its portfolio.

the application of linear programming in Excel has enabled Omega Bank Ltd to determine an optimal allocation of its ₦100 million loan fund, resulting in a maximum return of ₦12.1 million. This strategic distribution ₦30 million in Personal Loans, ₦40 million in Mortgage Loans, and ₦30 million in Business Loans ensures the full utilization of available funds while staying within critical regulatory and risk boundaries. By allocating 40% of the portfolio to Mortgage Loans, the bank not only complies with the minimum regulatory requirement of 30% but also benefits from the stability associated with this low-risk category.

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Equally important is the adherence to the cap of 50% on high-risk Personal Loans, which helps in maintaining the overall portfolio risk at an acceptable average score of 6. This demonstrates a disciplined approach to credit risk management, balancing the higher returns from riskier assets with more secure investments. The resulting return a well-balanced ₦12.1 million reflects the effectiveness of this allocation strategy.

Moreover, the use of Excel Solver for linear programming provided a practical and accessible platform to model complex financial decisions. It allowed Omega Bank Ltd to evaluate multiple constraints and objectives simultaneously, producing a solution that is both optimal and compliant. This data-driven methodology supports sound decision-making and reinforces the bank's commitment to maximizing shareholder value while mitigating risk.

Ultimately, this approach strengthens the bank's financial position and sets a strong foundation for future lending strategies rooted in analytical precision and regulatory awareness.

Recommendations

Omega Investments and Omega Bank Ltd should continue leveraging linear programming tools, such as Excel Solver, for ongoing portfolio optimization. Regular reviews of market conditions, regulatory changes, and asset performance are essential to maintain compliance and maximize returns. Diversifying further by exploring additional asset classes or loan products could enhance resilience. Additionally, integrating real-time data analytics and scenario analysis will improve decision-making under uncertainty. Both institutions should also invest in staff training to deepen internal expertise in financial modeling and risk management. By maintaining this data-driven, adaptive approach, they can secure long-term growth, sustainability, and competitive advantage in dynamic financial markets.

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