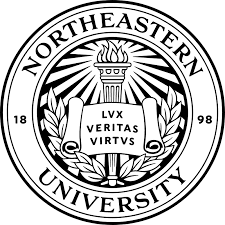
**Final Project: Optimization Models**



**ALY6050: Enterprise Analytics**

**Northeastern University**

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**Introduction**

In Part I, this report analyzes the shipping contract negotiation between Rockhill Shipping & Transport Company and Chimotoxic, a manufacturer of industrial chemicals. The proposed contract involves the transportation of hazardous waste from six plants to three waste disposal sites. The objective of this report is to determine the most cost-effective shipping routes that minimize Rockhill's expenses. Various factors, including shipping costs between plants and waste disposal sites, waste generation at each plant, and maximum capacity limitations at the disposal sites, will be taken into consideration. Additionally, the feasibility and potential cost savings of utilizing intermediate shipping points will be explored as an alternative option. By examining these factors, Allen aims to develop a contract proposal that offers an optimal solution for both Rockhill and Chimotoxic.

For Part II, we examine a portfolio composed of bonds, high tech stocks, foreign stocks, call options, put options, and gold. The expected returns for each asset type have been estimated based on historical data. Additionally, the covariance matrix is provided, offering insights into the relationships between the returns of different assets. By analyzing this information, we aim to assess the diversification potential and risk-return characteristics of the portfolio. The findings will enable the investor to make informed decisions regarding asset allocation and risk management.

**Analysis**

**Part I: Rockhill Shipping & Transport Co.**

Table : Cost per barrel (plant to site)



The Table 1 gives the cost per barrel for transporting the waste from 6 plants to 3 treatment sites. Our aim is to assess the minimum cost transport plan. We use linear optimization under the constraints of waste plant capacity and waste generated on weekly basis. The constraints are given below

Table : Waste generated per week



Table : Waste Site capacity per week



Table 4 below, gives us the solution for minimizing the transportation cost while transporting all the waste generated to the treatment sites. From the Denver plant, 36 barrels of waste must be dumped in Orangeburg, while 9 barrels in Florence. All of Morgantown & Morrisville waste shall be transported to Macon. Pineville waste should be taken to Florence site, Rockhill to Orangeburg, and Statesville ot be distributed between Florence and Macon. This approach will result in Total cost of $2988 per week. Orangeburg and Florence sites capacity will be fully utilized while Macon will have a slack of 17 barrels per week.

Table : Minimized Cost Transportation



Another method of transporting waste is also explored where each site and plant can serve as intermediate stop between the originating plant and final site. The cost per barrel associated with this model is given below in Table 5

Table : Cost per Barrel Intermediate stop model



Considering the cost above in addition to the cost in Table 1, we arrived at a different solution with minimized cost. The constraint of Waste site capacity still remained. Since the plants also function as intermediate stops therefore, the total waste present at a plant per week, is sum of waste generated by the plant and waste brought in to the plant by other plants. Since all the waste has to be transported, therefore, total waste present at plant shall be equal to total waste transported from the plant. With these constraints, we arrived at the solution in Table 6 below.

Table : Trans-shipment Model



With this model, our transportation costs reduced to $2674, saving us $314 from the previous model. We can see that all of Denver waste and 17 barrels of Pineville is transported to Morgantown and then transported to Florence and Macon sites. All of Morrisville waste will go to Macon. 36 units of Pineville will go to Orangeburg via Rockhill. Statesville waste will go to Florence. We can see that with a few adjustments in routes, the costs were lowered.

Each week 233 barrels of waste is moved from 6 plants to 3 treatment sites. Same as previous model, Only Macon site is underutilized by 17 units of waste per week.

**Part II: Investment Allocations**

Table 7 gives the expected returns for various investment options. With the budget of $10000, our aim is to achieve a certain percentage of ROI with minimum risk. The risk is a factor of variance in returns of an investment option. Table 8 gives the variance and co-variance matrix for investment options. The model is prepared with proportions and not the absolute values. Therefore the decision variables are proportions of amounts invested in assets.

Table : Expected Returns

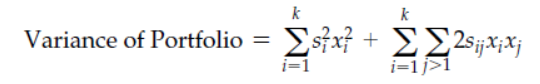
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The table below gives the variance the diagonal entries give the variance of the asset and non-diagonal entries shows to what degree the returns of two assets are related. For example, Bonds and High tech stocks have positive covariance while Foreign stocks have negative. Gold and Bonds have covariance of 0.0004 in returns

Table : Covariance Matrix of returns

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Following the Markowitz portfolio optimization model, the variance of the portfolio is given by



Where s2i is the sample variance in the return of stock i and sij = the sample covariance between stocks i and j

Xi represents the amount/share in investment i and Xj represents the amount/share in investment j. Therefore our objective becomes to minimize the total risk, or variance of the portfolio by choosing optimal amounts to invest in assets for desired return. Table 9 gives the variance and covariance factors of Portfolio. The objective function is the sum of all the entries in Table 9.

Table : Portfolio Variance Table



The constraints are of the total amount to be invested i.e. $10000 and the net return is atleast 11%. Therefore the optimum investment strategy is given in Table 10. The minimized risk was 0.00074.

Table : Optimum Investments



Considering the risk and the return of 11%, Foreign stocks and Put Options carry the major share of investments 27.1% and 25.45% and call options the least (4.8%).

Next we assess the minimum risk associated with portfolio returns ranging from 10% to 13.5%, which gives us the graph below. The value are given in Table 11

Figure : Minimized variance vs Returns

Table : MInimized risk vs return

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In Table 11 we can see from the slope that the risk increases almost 7 times with 3.50% increase in returns. The general relationship of higher risk with increased returns is established.

**Conclusion**

In the trans-shipment problem scenario the objective was to determine the most cost-effective shipping routes for transporting hazardous waste from six plants to three waste disposal sites. By considering the shipping costs between plants and waste disposal sites, waste generation at each plant, and maximum capacity limitations at the disposal sites, an optimal solution was sought. To tackle this problem, various techniques can be employed. One approach is to use linear programming to formulate a mathematical model that minimizes the total transportation cost while satisfying the waste generation and capacity constraints. By utilizing techniques such as the simplex method or network flow algorithms, the optimal shipping routes and quantities can be determined.

The portfolio analysis problem involved selecting a combination of assets to form an investment portfolio, considering their expected returns and the interrelationships between them. The objective was to construct a diversified portfolio that maximizes returns while minimizing risk. To address this problem, we used Markowitz portfolio optimization. It utilizes statistical measures such as expected returns, variances, and co-variances to construct an efficient frontier of portfolios that provide the highest expected return for a given level of risk or the lowest risk for a given level of return.

In both trans-shipment problem and portfolio analysis, the application of mathematical models, optimization algorithms, and statistical techniques play a crucial role in finding optimal solutions and facilitating decision-making processes. These tools provide a systematic approach to analyze complex problems, considering multiple variables and constraints, ultimately leading to more efficient and effective outcomes.

**References**

*Evans, J. R. (2013). Statistics, Data Analysis and Decision Modeling (Xth ed.). Pearson Education.*