**Module-6:** **Optimizing**

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*Subject:ALY6050: Introduction to Enterprise Analytics*

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**Introduction:**

The purpose of the assignment is to implement non-liner techniques to optimize the decision variables. In Part-1; we optimize the allocation of waste disposal between disposal sites and collection sites, whereas in Part-2 we derive the maximum return percentage to allocate weightage between the stocks and observe the trend between the expected return and variance.

**Part-1: Rockhill Shipping & Transport Company**

# **Given Variables:**

The data contains the below predominant variables:

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**Mathematical Formulation:**

To solve this problem using non-linear programming, we need to define decision variables, objective function as well as constraints. The objective function is to minimize the total shipping cost, which includes direct shipments and shipments through intermediate points. Therefore, the objective is:

Minimize *Z*= *i*∑​*j*∑​(*cij*​⋅*xij*​) + *i*∑​*k*∑​(*cik*​⋅*yik*​) + *j*∑​*k*∑​(*cjk*​⋅*zjk*​)

Where *cij*​, *cik*​, and cjk represent the shipping costs per barrel between plants and disposal sites, plants and plants (intermediate points), and between disposal sites, respectively.

Subject to the following constraints:

Supply constraints: The waste generated should not exceed its capacity:

∑​xij​ + k∑​yik ​>= Waste per Week (bbl)

Demand constraints: Waste sent to each disposal site should not exceed its capacity:

∑​xij​ + k∑​zjk ​≤ Disposal Site Capacity (bbl)

The amount of waste disposed from between the sites should be equal to the waste disposed to the site

Non-negativity constraints: xij, yik, and zjk ​≥ 0

**Solver and sensitivity report:**

I tried to minimize the transportation cost using objective function Z. It is initially calculated by using SUMPRODUCT function, of cost and amount of waste transported between the sites. Further, the constraints and inequalities have been set up; we should now calculate the amount that is shipped from and shipped to the disposal sites. This would be the sum of all variables I,e wasted disposed from Denver to remaining sites, in the similar way the sum for the remaining constraints is also calculated.  
Through solver form data tab, the objective function is set to minimum, and changing varies I,e quantity shipped is assigned and respective constraints have been assigned. Marked non-variables and using the “Simplex LP” method we solved the objective. Please refer to the Fig-1 and 2 for the findings.

**The optimal solutions:**

* **Optimal cost:**
  + The minimal cost achieved is $2743.
* **Total barrels transported each week:**

Total barrels transported each week = 36 + 9 + 0 + 0 + 0 + 0 + 0 + 26 + 42 + 29 + 37 + 0 + 63 = 242 barrels

* 9 barrels from Denver to Morganton
* 36 barrels from Denver to Orangeburg
* 26 barrels from Morganton to Florence
* 42 barrels from Morrisville to Macon
* 29 barrels from Rockhill to Orangeburg
* 37 barrels from Orangeburg to Florence
* 63 barrels from Orangeburg to Macon

Therefore, 242 barrels would be transported each week from the sources to the destination and the corresponding total cost is $2743.

**Part 2: Investment Allocations**

# **Given Variables:**

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# **(i)To determine the how much money should the investor invest in each stock (total investment of $10,000), with minimum expected return of 11% and with the minimum risk.**

**Objective:**

The objective is to invest $10,000 with minimum risk and return greater than 11%.

**Constraints:**

The sum of parts of investment should be equal to $10,000.

Expected return should be greater than or equal to 11%.

**Calculation Variables:**

**Invested Amount:** We need to derive total investment which is sum of all investments in stocks.

**Return**: We have the probability of expected retunes in each stock, hence the total return can be calculated by using SUMPRODUCT function among probabilities and variables covariance matrix

**Expected Return:** is the sum product of probability and return

**Variance (min risk):** is theproduct of respective probabilities with the square of difference between individual returns and expected return.

Now we have all the requited variables to calculate the amount invested, find the expected return and variance.

Using GRG Nonlinear method in solver, the objective is set to minimize the variance, the changing variables are assigned I,e investments in different stocks, and constraints, that invested amount is 10,000 and expected return greater than qual to 0.11 has been assigned.

From Fig-4; we can observe the optimal allocation.

| **Asset Type** | **Invested Amount** |
| --- | --- |
| Bonds | $7,264.19 |
| High tech stocks | $253.28 |
| Foreign stocks | $844.17 |
| Call options | $15.93 |
| Put options | $1003.23 |
| Gold | $619.20 |

This allocation minimizes portfolio variance while meeting the constraints of a minimum expected return of 11% and a total investment of $10,000.

**(ii) Use successive values of 10%, 10.5%, 11%, 11.5%, 12%, 12.5%, 13% and 13.5% as the baseline return values to obtain eight pairs of solutions (r, e). Plot “e” versus “r”.**

The variance (r) and expected return (e) for 11% have been calculated and using the similar approach, I derived the results for the remaining expected returns. Please refer to Fig-5 to Fig-11, for the respective values.

Form the results we obtained the below values:



The line plot for these values have been plotted, please refer to Fig-12. From the plot we observe that:

* As the expected portfolio return increases, the minimized risk tends to increase: For lower expected returns (around 3.2%), the minimized risk remains relatively constant at approximately 2.17. However, for higher expected returns (around 0.51%), the minimized risk increases to approximately 3.35.
* There is a nonlinear relationship between risk and return: The plot does not exhibit a simple linear relationship between risk and return. Instead, it seems to follow a more complex pattern, possibly exhibiting a convex shape.
* Diminishing marginal returns: At higher expected returns, the increase in minimized risk becomes more pronounced compared to the increase in expected return. This suggests diminishing marginal returns to risk reduction as the expected return increases.

Based on these observations, it appears that the relationship between risk and return is nonlinear and exhibits diminishing marginal returns.

**Conclusion:**  
The analysis of the optimal investment allocation, its corresponding risk-return relationship, and the observed patterns provide a nuanced understanding of portfolio management dynamics. The non-linear relationship between risk and return, as evidenced by the plot exhibiting a possible convex shape, underscores the intricate interplay between these two crucial factors. Notably, as the expected portfolio return increases, the minimized risk tends to escalate, indicating the inherent trade-off inherent in investment decisions. This observation aligns with conventional wisdom in finance, highlighting the need for investors to carefully balance their risk appetite with desired return objectives. Moreover, the diminishing marginal returns to risk reduction as expected return rises underscores the complexity of optimizing portfolios for risk-adjusted returns. Ultimately, the optimal investment allocation, meticulously crafted to minimize portfolio variance while adhering to constraints such as minimum expected return and total investment, underscores the significance of portfolio optimization techniques in navigating the intricate landscape of financial markets. This analysis accentuates the importance of informed decision-making in portfolio management, where investors must weigh the potential rewards against associated risks to achieve their investment goals effectively.

**Appendix:**

Fig-1: Case-1-Minimum Cost

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Fig-2: Case-1: Constraints

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Fig-3: Part-1: Sensitivity Report

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Fig-4: Part-2: Minimizing variance

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Fig-5: Expected Return at 10%

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Fig-6: Expected Return at 10.5%

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Fig-7: Expected Return at 11.5%

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Fig-8: Expected Return at 12%

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Fig-9: Expected Return at 12.5%

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Fig-10: Expected Return at 13%

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Fig-11: Expected Return at 13.5%

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Fig-11: e vs r plot

**References:**

ALY 6050: Module 6 — Optimizing

Yen-Ting Lin: Markowitz portfolio optimization in Excel; [online]: <https://www.youtube.com/watch?v=BDJxVYfKyag>

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Solver: Portfolio Optimization - Full Markowitz Method; [online]: <https://www.solver.com/portfolio-optimization-full-markowitz-method>