

CHEME 5660 Final Project: Optimizing Endowment Investment for Sustainable Pediatric Healthcare

Yanran Kuang*,

*School of Chemical and Biomolecular Engineering, Cornell University, Ithaca, NY 14850 USA

Abstract—This paper addresses the optimization of investment strategy for a non-governmental organization providing pediatric health services in Kampala, Uganda, over ten years. The project formulates an investment plan considering operational costs, capital expenditures, and endowment payback. The approach involves constructing a custom portfolio and "QQQ" and employing a minimum variance condition. Results indicate the chosen portfolio meets both operating and investment objectives. Comparative analyses with the SPY benchmark demonstrate superior performance in various metrics. Reallocation strategies further highlight the robustness of the chosen portfolio. The conclusions affirm the efficacy of the proposed investment strategy in fulfilling the NGO's financial goals.

I. INTRODUCTION

A non-governmental organization (NGO) is the beneficiary of a Bill and Melinda Gates Foundation grant that will provide additional pediatric health services to the greater Kampala, Uganda, area for ten years. The NGO will construct a physical facility and 15 satellite clinics. The NGO will receive an endowment to be invested in a portfolio, that will cover operational costs (utilities, people, supplies, etc.), capital cost, and pay back initial endowment value over the period of ten years. Some assumptions include: The endowment is a lump sum, to be determined. All incomes and costs are discounted continuously with a discount rate of 5% for all calculations. Extra 20% of annual operating cost is allocated for reinvestment payments. Lastly, Aside from the discount rate, operational costs are static.

II. PROCEDURE

A. Cost Breakdown

TABLE I
SUMMARY OF COSTS PER YEAR.

Cost Type	Quantity	Cost per Quantity	Total Cost
Personnel Cost: Physicians	30	21694.81	650844.3
Personnel Cost Physician Assistant	45	15278.21	687519.45
Utility & Supplies	15	120000	180000
Reinvestment Payment	1	627672.75	627672.75
Capital Expense (Yr. 0)	1	5000000	5000000

Each year, the operating costs include: 30 total doctors/physicians and 45 physician Assistants are paid 1338363.75 USD annually, based on average salaries reported on world-salaries.com; utilities and supplies cost 1800000.00 USD across all clinics annually, which sums up to a total operating cost of 3138363.75 USD. Additionally, a re-investment payment is to be made every year, which is an additional 20% of the operating expenses; this amounts to 627672.75 USD. Annually, the operating expenses sum up to 3766036.5 USD. To calculate

the total operating expenses over the course of 10 years, it is assumed that the annual operating cost is static in its face value, then the cost each year is converted to Net Present Value (NPV). Additionally, there is a capital expense of 5000000 USD. The total expenses for this entire period is 34080335.59 USD, which is approximately 34.08 Million. (See attached spreadsheet in the Github Repository for detailed calculations.)

B. Endowment Policy

The initial grant size must account for total expenses over the 10 year period, and allocate initial funds for investment. The total expenses for this entire period is 34080335.59 USD (\$34.08 Million), discounted to Present Value. An additional allocation of 24000000 (\$24 Million) will be used solely for investing into a profitable portfolio. Thus, the total value of the endowment / initial grant size will be \$58080335.59 (\$58.08 Million). No additional grant will be required. At the end of the 10 year period, the face value of the initial grant must be paid back. Thus, the portfolio's expected value at the end of the 10 year period, discounted to NPV, must be at minimum of 58.08 Million USD.

III. RESULTS

The chosen portfolio consist of the tickers "MSFT", "AMD", "NVDA", "RCL", "PHM", "V", "SPY", and "QQQ". This portfolio was evaluated in its performance by projecting its worth to 10 years (defined as 2520 trading days) later, using the minimum variance condition. After the portfolio was chosen, it was analyzed in the minimum variance allocation problem. The initial fund was \$24 Million. A minimum desire reward level is selected, then efficient frontier that represents a set of portfolios that offer the highest expected return for that desired return. The expected value of the return at the end of the 10 year period was calculated, discounted to present value.

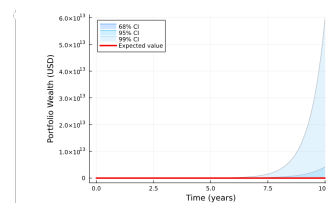


Fig. 1. Performance of Custom Portfolio over 10 Years

As Figure 1 shows, At the end of term, The selected portfolio should be worth (L,E,U) = (1.194443057e7, 8.9069644711e8, 6.641925339216e10) USD, in terms of lower bound (minimum return), expected return, and upper bound(maximum return). The expected value for this portfolio, discounted to Present Value is

5.16234703669327e8 USD, which is equal to 516.23 Million. In both face value and in NPV, investment from this portfolio is sufficient to pay back the initial endowment. Thus, this portfolio fulfilled both operating expenses objective and the investment objective.

A. Comparison to SPY Benchmark - Various Metric

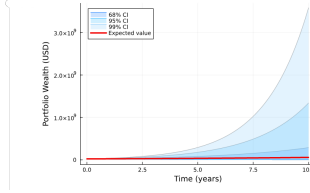


Fig. 2. Performance of SPY Only Portfolio over 10 Years

1) *SPY's Projection to 10 years:* For one comparison, a portfolio consist only with SPY also had its worth projected to 10 years (2520 trading days) later. As Figure 2 shows, the SPY only portfolio should be worth (L,E,U) = (1.189932352e7, 5.869966802e7, 2.8956696729e8) USD, in terms of lower bound, expected return, and upper bound. The expected value for SPY only portfolio, discounted to Present Value is 1.1603148369083174e7 USD, which is equal to 11.60 Million. Thus, the custom portfolio yields a greater expected returned compared to the SPY only portfolio: 516.23 Million is greater than 11.60 Million.

2) *Comparison of projection to 6 years:* For another comparison, the projections of both portfolios using the minimum variance method is calculated and visually represented over the course of 1489 days (approximately 6 years). The present values of both portfolios' expected returns were also calculated. Figure 3 shows that in in first half of the investment period, there were instances in which SPY only portfolio has a greater return than the custom portfolio. However, towards Year 6, the custom portfolio was performing slightly better than SPY only. Additionally, it was determined that at the end of the 6 year period, the expected NPV for SPY ONLY portfolio is equal to 6.293622460728738e6USD (approx. 6.294 Million). The expected NPV for custom portfolio is equal to 1.2702053264782625e8USD (approx. 127.02 Million). This implies that halfway in the investment period, the custom portfolio will begin to outperform the SPY Only portfolio.

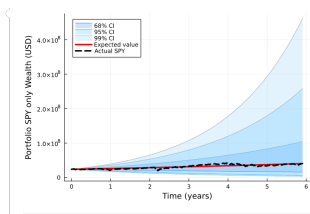


Fig. 3. Performance of custom vs SPY Only Portfolios over 6 Years

3) *Comparison using Reallocation:* A possible strategy that was considered in order to boost the value of the custom portfolio was using reallocation. The tickers remained the same, but the distribution of fund to each stock was reallocated within the portfolio after the close of every trading day. An initial portfolio was selected from the imported efficient frontier. The portfolio is then reallocated at the end of each trading days based on the portfolio state and reward from a taken action (sell, hold,

or buy). The performances of the initial portfolio, reallocated portfolio and the benchmark SPY only portfolio were evaluated and demonstrated in Figure 4 below.

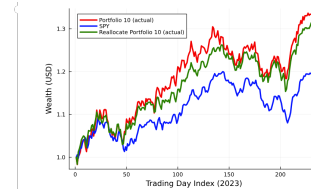


Fig. 4. Performance of custom vs custom reallocated vs SPY Only Portfolios

This comparison is limited by the small window of trading days, up to a total of 230. However, it is sufficient to suggest that the SPY Only portfolio was the worst performing one of of the three. Thus, it suggests, based on the first year's data, that the custom portfolio should be chosen in order to generate enough return to repay the endowment. In particular, the initial portfolio compared with the reallocated portfolio doesn't seem to vary significantly in terms of wealth ratio (final wealth over initial wealth).

IV. DISCUSSION

The discussion should be three paragraphs (or less).

A. Results and Implications

The custom portfolio consisting of the tickers "MSFT", "AMD", "NVDA", "RCL", "PHM", "V", "SPY", and "QQQ" is an optimal portfolio to select for investment. Its expected return at the end of the 10 year period is sufficient to pay back the face value of the initial endowment, and all expenses for operating the central facilities along with the 15 satellite clinics. In comparison to the benchmark portfolio: multiple performance metrics were tested on both portfolios, and the results show that the custom portfolio outperformed the SPY only portfolio in all three metrics.

B. Alternative Approaches

One alternative approaches could involve different portfolio constructions or investment strategies. Another approach might involve diversifying across various asset classes, such as bonds or real estate, to balance risk and return.

C. Limitations

Limitations include the assumptions made for the purpose of the project, such as static costs and fixed discount rates. Other limitations include using limited data to inform decisions made for the next 10 years, which can yield a lot of uncertainty.

V. DATA AND MODEL AVAILABILITY

The model equations were implemented in Julia (v.1.9.2) [1] The model code is available at <https://github.com/varnerlab/CHEME-5660-GroupProject-Template-F23.git>

REFERENCES

1. Bezanson, J., Edelman, A., Karpinski, S. & Shah, V. B. Julia: A fresh approach to numerical computing (2014). arXiv:1411.1607.