

Workshop Report 3

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1. Framing the portfolio selection problem

Mathematical formulation:

Define Sets:

Project i belongs to oncology if $1 \leq i \leq 16$

Project i belongs to cardiovascular if $17 \leq i \leq 36$

Project i belongs to respiratory and dermatology if $37 \leq i \leq 53$

Project i belongs to transplantation if $54 \leq i \leq 63$

Project i belongs to rheumatology and hormone therapy if $64 \leq i \leq 85$

Project i belongs to central nervous system if $86 \leq i \leq 103$

Project i belongs to ophthalmic if $104 \leq i \leq 114$

Constants:

c_i : the development cost for the coming year for project i

t_i : the time to complete project i

y_i : ENPV to be obtained if project i is completed

Decision Variable:

$x_i = 1$ if project i is fully funded and selected into the portfolio and $x_i = 0$ if it was not funded at all and its development was postponed.

Objective is to maximize the ENPV of the drug portfolio:

$$\max \sum_{i=1}^{114} y_i x_i$$

Constraints:

1. Therapeutic area budget constraints:

$$\begin{aligned} \sum_{i=1}^{16} c_i x_i &\leq 100 & \sum_{i=17}^{36} c_i x_i &\leq 200 \\ \sum_{i=37}^{53} c_i x_i &\leq 150 & \sum_{i=54}^{63} c_i x_i &\leq 100 \\ \sum_{i=64}^{85} c_i x_i &\leq 300 & \sum_{i=86}^{103} c_i x_i &\leq 100 \\ \sum_{i=104}^{114} c_i x_i &\leq 50 \end{aligned}$$

2. Drug development pipeline constraints:

$$\begin{aligned} \frac{\sum_{j=1}^{114} x_j}{\sum_{i=1}^{114} x_i} &\geq 0.15 \text{ if } t_j = 1 \\ \frac{\sum_{j=1}^{114} x_j}{\sum_{i=1}^{114} x_i} &\geq 0.2 \text{ if } (t_j \geq 2 \text{ and } t_j \leq 3) \\ \frac{\sum_{j=1}^{114} x_j}{\sum_{i=1}^{114} x_i} &\geq 0.25 \text{ if } (t_j \geq 4 \text{ and } t_j \leq 5) \end{aligned}$$

3. $x_i \in \{0,1\} \forall i = 1, \dots, 114$

The drugs to continue developing:

3, 4, 6, 7, 13, 15, 17, 18, 20, 21, 22, 24, 25, 27, 28, 29, 30, 40, 42, 43, 44, 45, 47, 48, 49, 50, 53, 57, 58, 62, 66, 69, 72, 76, 77, 78, 86, 91, 94, 97, 98, 99, 100, 101, 102, 104, 105, 106, 109, 110, 111, 112, 113

The other drugs are put on hold.

The portfolio cost is 924.11 million dollars, portfolio ENPV is 23023.9 million dollars, portfolio standard deviation is 4556.97 and portfolio variance is 2.0766e+07.

92.411% of the overall budget is used for drug development.

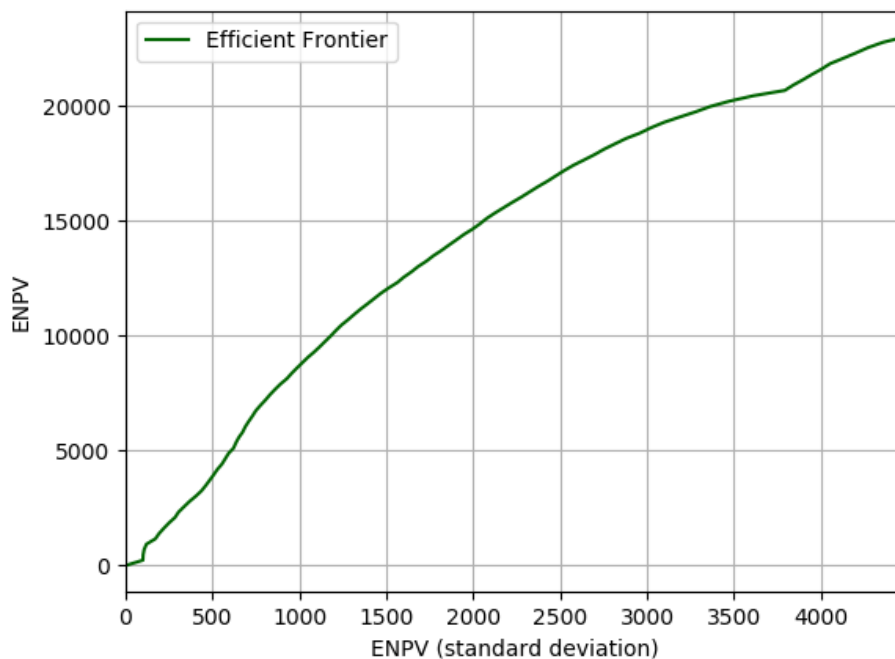
2. Incorporating risk management in the analysis

σ_{ij} is the return covariance between project i and j

Mathematical formulation:

The added constraint is:

$$\sum_{i=1}^{114} \sum_{j=1}^{114} x_i \sigma_{ij} x_j \leq K \quad K \leq 2.0766e + 07$$



Based on the efficient frontier, I would recommend taking half the maximum risk which has ENPV standard deviation of 2250 since the company can achieve this with portfolio ENPV of around 16000 which is only 30% less than the maximum possible ENPV. It greatly reduces risk but has small impact on ENPV.

In this scenario, the drugs to be developed will be 4, 5, 6, 11, 20, 21, 22, 25, 26, 27, 29, 30, 37, 39, 42, 45, 48, 50, 53, 57, 62, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 75, 78, 79, 80, 82, 86, 87, 91, 94, 95, 97, 98, 100, 101, 102, 103, 104, 105, 108, 109, 111, 112

The portfolio cost is 806.19 million dollars, portfolio ENPV is 15917 million dollars, portfolio standard deviation is 2249.74 and portfolio variance is 5.06132e+06. 80.619% of the overall budget is used for drug development.

If the portfolio risk were to be minimized, no drugs would be chosen for development since the minimum risk could be 0 and ENPV will also be 0. Because the company has the alternative option of investing risk free with a return of 3%, and any additional drug development will increase the risk the company will be taking, the company won't develop drugs.

I would recommend allocating the additional 50 million to Oncology if the goal is to maximize profit.

The allocation of the additional \$50 million will shift from Oncology to Cardiovascular, Transplantation, Respiratory and dermatology, Rheumatology and hormone therapy, Respiratory and dermatology and finally back to Oncology as the company's willingness to take risk increases.

The result indicates the company shifts its focus to areas with more risky but more rewarding drug development projects gradually as it wills to take more risks. Different risk tolerance will require different allocation of the additional fund to achieve optimal.

3. Company-wide budgeting

Mathematical formulation:

The therapeutic area budget constraints are replaced by a single company-wide budget constraint:

$$\sum_{i=1}^{114} c_i x_i \leq 1000$$

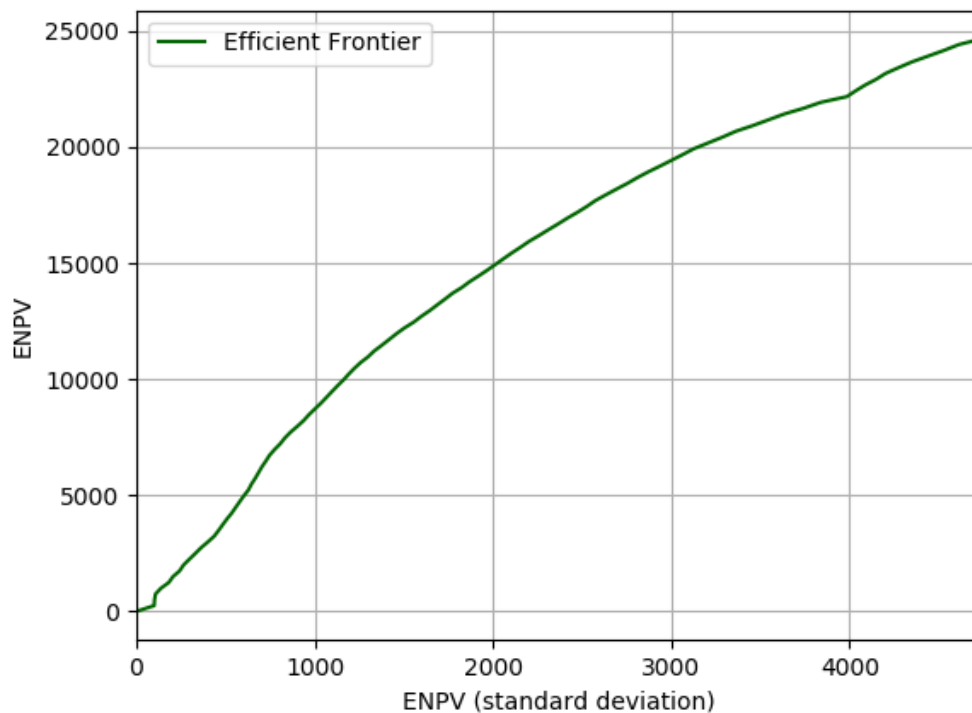
In this scenario, the drugs to be developed will be 3, 4, 5, 6, 11, 13, 16, 17, 18, 20, 21, 22, 24, 25, 26, 27, 28, 30, 39, 40, 42, 43, 44, 47, 48, 50, 53, 57, 58, 62, 66, 68, 69, 72, 73, 74, 75, 76, 77, 78, 86, 91, 98, 99, 101, 102, 104, 105, 106, 109, 110, 111, 112

The portfolio cost is 986.95 million dollars.

The portfolio ENPV is 24661.8 million dollars, which is 1637.9 million dollars more

The portfolio standard deviation is 4742.26, which is 185.29 more.

The percent of funds allocated is 98.695% which is 6.284% more.



The efficient frontier is slightly higher than the previous efficient frontier at all points.

I would recommend Zinca to use company-wide budget since for a certain amount of risk the company takes, the company-wide budget will yield higher maximum ENPV and thus is more favourable.

4. Managing extreme risks

The minimum risk measured in the highest attainable VaR of the portfolio's ENPV at the 5th percentile is 4463.39. The expected return of the portfolio is 22992.5 million dollars. Portfolio VaR at 5th percentile is 15650.3 million dollars and the percent of funds allocated is 87.337%.

Zinca should not be concerned about the extreme risk of its current drug portfolio since minimizing risk measured in highest VaR at 5th percentile only decreases portfolio standard deviation by 93.58 which is very small compared to the absolute amount of the risk. Since this risk management measure is not very effective, Zinca doesn't have to account for the extreme risk.