# Mixed Integer Linear Programming for Portfolio Optimization Bay Area Decision Science Summit 2025


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## ABSTRACT

Our team explored the application of a Mixed Integer Linear Programming (MILP) approach to optimize the portfolio of equity derivatives by minimizing the net costs spent on options over a given period. By utilizing MILP, our approach ensures a minimum exposure of +\$10,000,000 for a given scenario, while minimizing the total premium costs across a time frame of one month.



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## 1 NET COSTS APPROACH

### 1.1 Definitions

- The set of options $o \in O$.
- The set of trading dates $d \in D$.

### 1.2 Decision Variable

First, define the set of non-expired options for day $d$, given by:

$$O_d = \{o \in O \mid T_o \geq d + 1\}$$

Hence, for each option $o \in O_d$, define:

$$x_{o,\,d} \in \mathbb{Z}^+ := \text{ number of } \textbf{contracts} \text{ to buy.}$$

### 1.3 Parameters

For each option $o \in O$:

- $a_o$ : Ask Price
- $A_o$ : Ask Size
- $M$ : Contract Size
- $k_o$ : Strike Price
- $s_o$ : Underlying Price
- $d_o$ : Trading Date
- $T_o$ : Maturity Date
- $\beta_{S(o),\,d}$ : Spot Move for option $o$ of tick symbol $S$ on day $d$.

#### 1.3.1 Exposure Function (per Option)

*We know that the next day underlying price is based on spot move. Hence, the exposure function, E, that takes in an option o and day d, is given by:*

$$E(o, d) = \max(s_o \cdot \beta_{S(o),\,d} - k_o\,,\ 0) - \max(s_o - k_o, 0)$$

#### 1.3.2 Carried Exposure

*We know that min exposure* $\geq 10,000,000\ \forall d \in D$. *Hence, for a given day, d, we define carried exposure,* $C_d$*, as the total exposure from positions bought on earlier days* $d' < d$ *that have not matured, given by:*

$$C_d = M \sum_{\substack{o \in O_d \\ d' \leq d}} x_{o,d'} \cdot E(o, d')$$

### 1.4 Objective Function & Constraints

With this approach, we want to minimize total premium cost over all options. For each day $d$, this yields:

$$\boxed{\min \sum_{o\,\in\,O_d} M(a_o \cdot x_{o,\,d})}$$

**Subject to:**

(i) **Purchase Limits:** $x_{o,\,d} \leq A_o\ \forall o \in O_d$
(ii) **Expiry:** For any option $o$ where $d_o \geq T_o$ , set $x_{o,\,d} = 0$.
(iii) **Daily Minimum Exposure:**
For each training date $d \in D$ such that $d + 1 \in D$, our **aggregate exposure** must meet the minimum:

$$C_d + M \sum_{o\,\in\,O_d} x_{o,\,d} \cdot E(o, d) \geq 10,000,000$$

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