

利益最大化目的関数

$$\begin{aligned}
& \max \quad \sum_{j=1}^J \sum_{n=1}^N v_j \times y_{j,n} \\
& \quad - \sum_{i=1}^I \sum_{r=1}^R \sum_{j=1}^J \sum_{n=1}^N c_{i,r} \times TR_{i,n,r} \times x_{i,r,j,n} \\
& \text{s.t.} \quad \sum_{j=1}^J \sum_{n=1}^N TR_{j,n,r} \times x_{i,r,j,n} \leq TP_{i,r} \quad (\forall i, \forall r) \\
& \quad \begin{cases} x_{i,r,j,n} = 0 & (\text{if } y_{j,n} = 0) \\ \sum_{i=1}^I \sum_{n=1}^N TR_{j,n,r} \times x_{i,r,j,n} \\ \quad = TR_{j,n,r} & (\text{if } y_{j,n} = 1) \end{cases} \\
& \quad \sum_{i=1}^I x_{i,r,j,n} \leq 1 \quad (\forall r, \forall j, \forall n) \\
& \quad \sum_{n=1}^N x_{i,r,j,n} \leq 1 \quad (\forall i, \forall r, \forall j) \\
& \quad \sum_{n=1}^N y_{j,n} \leq 1 \quad (\forall j) \\
& \quad \sum_{i=1}^I \sum_{n=1}^N \sum_{r=1}^R PAY_{i,r,j,n} \leq v_{j,n} \quad (\forall j, \forall n) \\
& \quad x_{i,r,j,n}, y_{j,n} \in 0, 1
\end{aligned}$$

コスト最小化

$$\begin{aligned}
\min \quad & \sum_{j=1}^J \alpha \left(1 - \sum_{n=1}^N y_{j,n} \right) + \sum_{i=1}^I \sum_{r=1}^R \sum_{j=1}^J \sum_{n=1}^N c_{i,r} \times TR_{j,n,r} \times x_{i,r,j,n} \\
\text{s.t.} \quad & \sum_{j=1}^J \sum_{n=1}^N TR_{j,n,r} \times x_{i,r,j,n} \leq TP_{i,r} \quad (\forall i, \forall r) \\
& \begin{cases} x_{i,r,j,n} = 0 & (\text{if } y_{j,n} = 0) \\ \sum_{i=1}^I \sum_{n=1}^N TR_{j,n,r} \times x_{i,r,j,n} = TR_{j,n,r} & (\text{if } y_{j,n} = 1) \end{cases} \\
& \sum_{i=1}^I x_{i,r,j,n} \leq 1 \quad (\forall r, \forall j, \forall n) \\
& \sum_{n=1}^N x_{i,r,j,n} \leq 1 \quad (\forall i, \forall r, \forall j) \\
& \sum_{n=1}^N y_{j,n} \leq 1 \quad (\forall j) \\
& \sum_{i=1}^I \sum_{n=1}^N \sum_{r=1}^R PAY_{i,r,j,n} \leq v_{j,n} \quad (\forall j, \forall n) \quad x_{i,r,j,n}, y_{j,n} \in 0, 1
\end{aligned}$$

提供単価最小化

$$\begin{aligned}
\min \quad & \sum_{j=1}^J \alpha \left(1 - \sum_{n=1}^N y_{j,n} \right) + \sum_{i=1}^I \sum_{r=1}^R \sum_{j=1}^J \sum_{n=1}^N p_{i,r} \times TR_{j,n,r} \times x_{i,r,j,n} \\
\text{s.t.} \quad & \sum_{j=1}^J \sum_{n=1}^N TR_{j,n,r} \times x_{i,r,j,n} \leq TP_{i,r} \quad (\forall i, \forall r) \\
& \begin{cases} x_{i,r,j,n} = 0 & (\text{if } y_{j,n} = 0) \\ \sum_{i=1}^I \sum_{n=1}^N TR_{j,n,r} \times x_{i,r,j,n} = TR_{j,n,r} & (\text{if } y_{j,n} = 1) \end{cases} \\
& \sum_{i=1}^I x_{i,r,j,n} \leq 1 \quad (\forall r, \forall j, \forall n) \\
& \sum_{n=1}^N x_{i,r,j,n} \leq 1 \quad (\forall i, \forall r, \forall j) \\
& \sum_{n=1}^N y_{j,n} \leq 1 \quad (\forall j) \\
& \sum_{i=1}^I \sum_{n=1}^N \sum_{r=1}^R PAY_{i,r,j,n} \leq v_{j,n} \quad (\forall j, \forall n) \quad x_{i,r,j,n}, y_{j,n} \in 0, 1
\end{aligned}$$

変数の説明

$PAY_{i,r,j,n}$: 企業 i と企業 j が入札 n において
リソース r を取引する価格

$x_{i,r,j,n}$: 企業 i と企業 j が入札 n において
リソース r を取引するとき 1,
しないとき 0 となる決定変数

$y_{j,n}$: 企業 j の入札 n が選ばれるとき 1,
選ばれないとき 0 となる決定変数

提供企業 1

$$\begin{aligned} & [(c_{1,1}, TP_{1,1}, TP_{1,2}), (c_{1,2}, TP_{1,1}, TP_{1,2}) \cdots] \\ & = [(0.1, 125, 0), (0.2, 0, 100) \cdots] \end{aligned}$$

提供企業 2

$$\begin{aligned} & [(c_{1,1}, TP_{1,1}, TP_{1,2}), (c_{2,2}, TP_{1,1}, TP_{2,2}) \cdots] \\ & = [(0, 0, 0), (0.5, 0, 200) \cdots] \end{aligned}$$

要求企業 1

$$\begin{aligned} & [(v_{1,1}, TR_{1,1,1}, TR_{1,1,2}) \cdots] \\ & = [(150, 150, 0) \cdots] \end{aligned}$$

要求企業 2

$$\begin{aligned} & [(v_{2,1}, TR_{2,1,1}, TR_{2,1,2}) \cdots] \\ & = [(200, 100, 50) \cdots] \end{aligned}$$

取引価格

$$PAY_{i,r,j,n} = \frac{c_{i,r} + v_{i,j} \times \left(\frac{TR_{j,n,r}}{\sum TR_{j,n}} \right)}{2} \times TR_{j,n,r}$$

$$\sum TR_{j,n} = \sum_{r=1}^R TR_{j,n,r}$$

$$PAY_{i,r,j,n} = p_{i,r} \times TR_{j,n,r}$$

定式化

$$\begin{aligned}
& \max \quad \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} v_j \times y_{j,n} - \sum_{i \in \mathbf{I}} \sum_{r \in \mathbf{R}} \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} c_{i,r} \times x_{i,r,j,n} \\
& \text{s.t.} \quad \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} x_{i,r,j,n} \leq TP_{i,r} \quad (\forall i, \forall r) \\
& \quad \begin{cases} x_{i,r,j,n} = 0 & (\text{if } y_{j,n} = 0) \\ \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} x_{i,r,j,n} = TR_{j,n,r} & (\text{if } y_{j,n} = 1) \end{cases} \\
& \quad \sum_{n \in \mathbf{N}_j} y_{j,n} \leq 1 \quad (\forall j) \\
& \quad x_{i,r,j,n} \in 0, 1 \\
& \quad y_{j,n} \in \mathbf{Z} \\
& \max \quad V(\mathbf{I}, \mathbf{J}, \mathbf{Q}) = \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} v_j \times y_{j,n} - \sum_{i \in \mathbf{I}} \sum_{r \in \mathbf{R}} \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} c_{i,r} \times x_{i,r,j,n} \\
& \text{s.t.} \quad \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} x_{i,r,j,n} + \sum_{i \in \mathbf{I}} \sum_{r \in \mathbf{R}} q_{i,r} \leq TP_{i,r} \quad (\forall i, \forall r) \\
& \quad \begin{cases} x_{i,r,j,n} = 0 & (\text{if } y_{j,n} = 0) \\ \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} x_{i,r,j,n} = TR_{j,n,r} & (\text{if } y_{j,n} = 1) \end{cases} \\
& \quad \sum_{i \in \mathbf{I}} q_{i,r} = Q_r \\
& \quad \sum_{n \in \mathbf{N}_j} y_{j,n} \leq 1 \quad (\forall j) \\
& \quad x_{i,r,j,n} \in 0, 1 (\forall i, \forall r, \forall j, \forall n) \\
& \quad y_{j,n} \in \mathbf{Z} (\forall j, \forall n) \qquad \qquad \qquad q_{i,r} \in \mathbf{Z} (\forall i, \forall r)
\end{aligned}$$

勝者となった入札のみを集めた問題

$$\begin{aligned}
& \max \quad V(\tilde{\mathbf{I}}, \mathbf{J}) \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} v_j \times y_{j,n} - \sum_{i \in \tilde{\mathbf{I}}} \sum_{r \in \mathbf{R}} \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} c_{i,r} \times x_{i,r,j,n} \\
& \text{s.t.} \quad \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} x_{i,r,j,n} \leq TP_{i,r} \quad (\forall i, \forall r) \\
& \quad \begin{cases} x_{i,r,j,n} = 0 & (\text{if } y_{j,n} = 0) \\ \sum_{j \in \mathbf{J}} \sum_{n \in \mathbf{N}_j} x_{i,r,j,n} = TR_{j,n,r} & (\text{if } y_{j,n} = 1) \end{cases} \\
& \quad \sum_{n \in \mathbf{N}_j} y_{j,n} \leq 1 \quad (\forall j) \\
& \quad x_{i,r,j,n} \in 0, 1 \\
& \quad y_{j,n} \in \mathbf{Z}
\end{aligned}$$