INDR371 - HW2

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Question 1

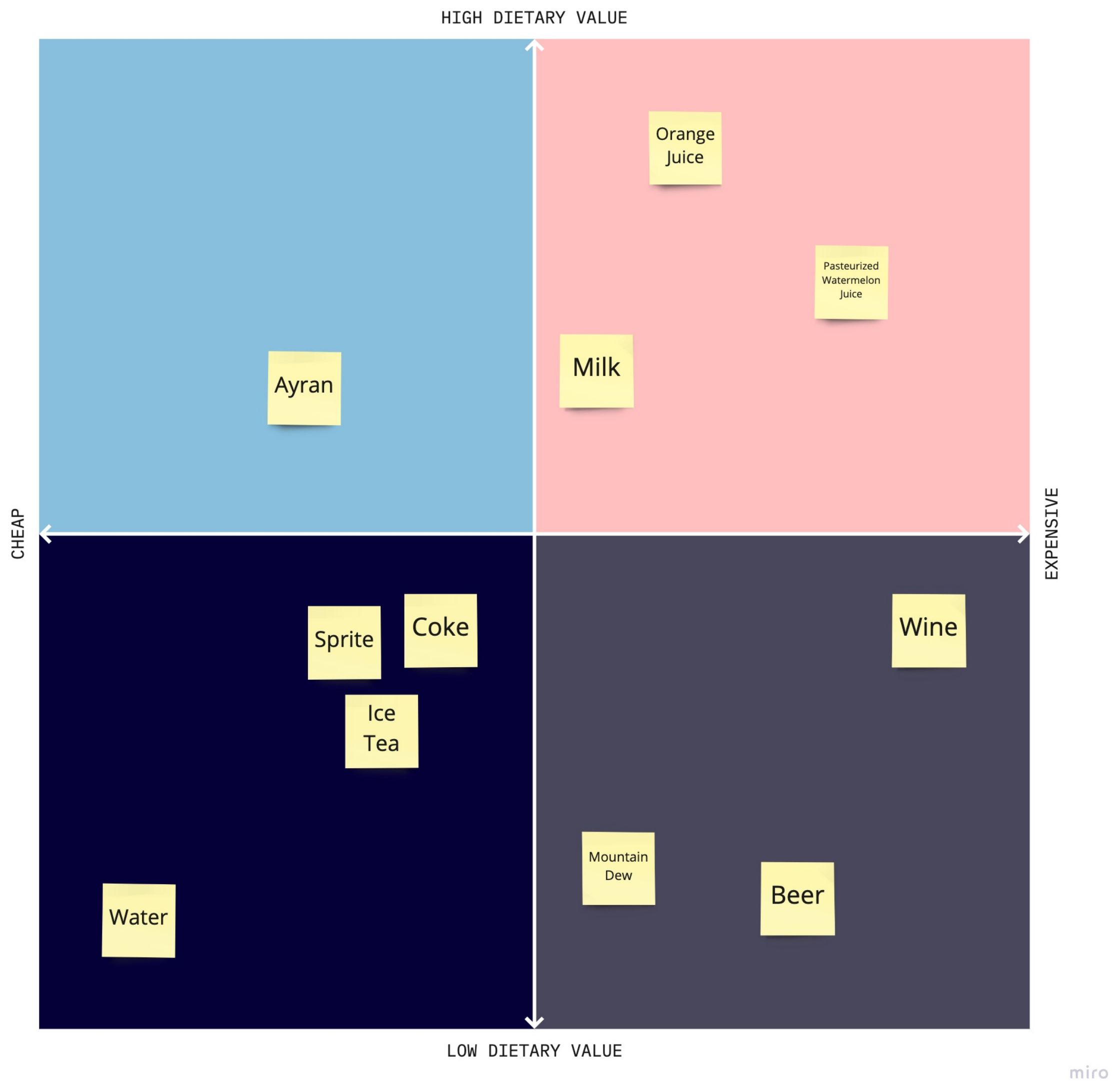

Figure 1: Gap Map for pasteurized watermelon juice

Question 2

I am really bad at drawing so I'll just write my ideas on packaging for three package types: glass, plastic and aluminium considering manufacturing, logistics and life-cycle perspectives.

Manufacturing: Manufacturing plastics is easier and cheaper than manufacturing glass and aluminium.
Logistics: Glass can easily be broken and the loss of product should be more than plastic and aluminium packages.
Life-cycle management: Currently, there is a high demand for products that are eco-friendly, therefore glass and aluminium packages would be better than plastic packages.

Considering the aspects above, if the price is high enough to tolerate the loss of products in transportation and the packaging material cost, I would prefer a glass or aluminium package.

Question 3

Part A

- c_1: unit cost of in-house production
- c_2: unit cost of subcontracted item
- c_3: capacity investment cost
- c_4: unit cost of operation per period
- K: production capacity
- h: holding cost per item in inventory per period
- x_t: in-house production quantity in period t
- y_t: subcontracted quantity in period t
- I_t: inventory level in the beginning of period t ($I_1 = I_{T+1} = 0$, assuming that inventory is zeroed after the period cycle)
- z_t: in-house production investment indicator for period t
- j: in-house production investment indicator

$$
\begin{array}{lll}
\min & \sum_{t=1}^{T} c_1 x_t + \sum_{t=1}^{T} c_2 y_t + c_3 j + \sum_{t=1}^{T} h I_t + \sum_{t=1}^{T} c_4 z_t & \\
\text{s.t.} & I_{t+1} = I_t + x_t + y_t - d_t & t = 1, 2, .., T \\
 & x_t \leq z_t K & t = 1, 2, .., T \\
 & I_t \geq 0 & t = 2, 3, .., T \\
 & x_t \geq 0 & t = 1, 2, .., T \\
 & j \geq z_t & t = 1, 2, .., T \\
 & z_t \geq z_{t-1} & t = 2, 3, .., T \\
 & I_{T+1} = 0 & \\
 & j \in \{0, 1\} & \\
 & z_t \in \{0, 1\} & t = 1, 2, .., T
\end{array}
$$

Part B

- c_1^t: unit cost of in-house production in period t
- c_2^t: unit cost of subcontracted item in period t
- c_3: capacity investment cost
- c_4: unit cost of operation per period
- Y_t: maximum amount you can buy from supplier at period t
- K: production capacity
- h: holding cost per item in inventory per period
- x_t: in-house production quantity in period t
- y_t: subcontracted quantity in period t
- I_t: inventory level in the beginning of period t ($I_1 = I_{T+1} = 0$, assuming that inventory is zeroed after the period cycle)
- z_t: in-house production investment indicator for period t
- j: in-house production investment indicator

$$
\begin{array}{lll}
\min & \sum_{t=1}^{T} c_1^t x_t + \sum_{t=1}^{T} c_2^t y_t + c_3 j + \sum_{t=1}^{T} h I_t + \sum_{t=1}^{T} c_4 z_t & \\
\text{s.t.} & I_{t+1} = I_t + x_t + y_t - d_t & t = 1, 2, .., T \\
& x_t \leq z_t K & t = 1, 2, .., T \\
& y_t \leq z_t Y_t & t = 1, 2, .., T \\
& I_t \geq 0 & t = 2, 3, .., T \\
& x_t \geq 0 & t = 1, 2, .., T \\
& j \geq z_t & t = 1, 2, .., T \\
& z_t \geq z_{t-1} & t = 2, 3, .., T \\
& I_1 = 0 & \\
& I_{T+1} = 0 & \\
& j \in \{0, 1\} & \\
& z_t \in \{0, 1\} & t = 1, 2, .., T
\end{array}
$$

Part C

In my solution, there is no procurement and we do in-house production in each period. For inventory levels, only I_{31} was nonzero ($I_{31} = 66$). More details can be found in the Jupyter notebook file.

```
Gurobi Optimizer version 9.5.2 build v9.5.2rc0 (mac64[rosetta2])
Thread count: 8 physical cores, 8 logical processors, using up to 8 threads
Optimize a model with 313 rows, 210 columns and 728 nonzeros
Model fingerprint: 0x39c18047
Variable types: 157 continuous, 53 integer (53 binary)
Coefficient statistics:
  Matrix range     [1e+00, 4e+02]
  Objective range  [5e-01, 2e+03]
  Bounds range     [1e+00, 1e+00]
  RHS range        [3e+00, 2e+02]
Found heuristic solution: objective 73321.300000
Presolve removed 262 rows and 58 columns
Presolve time: 0.01s
Presolved: 51 rows, 152 columns, 202 nonzeros
Variable types: 152 continuous, 0 integer (0 binary)

Root relaxation: objective 5.782600e+04, 100 iterations, 0.00 seconds (0.00 work units)

    Nodes    |    Current Node    |     Objective Bounds      |     Work
 Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time

*    0     0               0    57826.000000 57826.0000  0.00%     -    0s

Explored 1 nodes (100 simplex iterations) in 0.04 seconds (0.00 work units)
Thread count was 8 (of 8 available processors)

Solution count 1: 57826

Optimal solution found (tolerance 1.00e-04)
Best objective 5.782600000000e+04, best bound 5.782600000000e+04, gap 0.0000%
```

Figure 2: Gurobi result of the model