PROJECT REPORT

«Optimisation of supply network for importing coffee beans»

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1 Introduction

This report aims to tackle optimisation of coffee beans imports from suppliers into EU. The main objective is to reduce import costs as much as possible while meeting all required obligations. Charles team has provided us with all information necessary to make optimal decisions, this includes: docks to import coffee beans through with their corresponding tariffs for containers along with sign-up costs and throughput capacities. Also we have been given estimated quantity of coffee beans required to operate this year (1.5 million tons).

dock	40_ft_container_price_eur	max_capacity
Rotterdam	470	33000
Antwerp	470	25000
Hamburg	480	44000
Amsterdam	610	11000
Marseille	380	9000
Algeciras	280	20000
Valencia	310	11000
Genoa	340	7500

Table 1: Data on docks

2 Methodology

In order to solve this problem we propose using mathematical programming, where we define mathematical problem that reflects our aim to minimise import costs at the same being in line with other goals and constraints. We will use Python Pulp package for setup of this problem and finding solution itself. As a result, such approach will yield us mathematically the most optimal strategy that will save us as much money as possible. In the next section we will cover the setup of these problems along with approaches to their solution.

3 Analysis

In this section we will dive deeper into more rigorous mathematical definition of the problems along with their solutions. Then, we will provide deeper insights into obtained solutions applicable to the business.

3.1 Problem 1

In the previous year we would stick to the following strategy where 80% of Beanie Limited's containers entered through Rotterdam and the remaining 20% through Amsterdam. Also we know that the total cost of importing those 24000 containers was 13.7 million €. This would imply that on average each container costs 571 € to import. From the above table (1) we could see that such 80, 20 percent split between Rotterdam and Amsterdam will yield an average price of 498 which is still above some of the options left out. Why did we choose these when there are options like Algeciras where the price is at measly 280. That is why there is plenty of room for improvement in terms costs which we will discuss now.

3.2 Problem 2

In this section we will try to redistribute supply across multiple docks so that the costs are as least as possible. But still we have to take into account maximum capacity of each dock, unfortunately, we can not just pick one with least price and call it day. Therefore, it is our first constraint we have to consider. Also we have to import a certain amount of coffee beans, hence it is our second constraint to meet the requirement of importing 1.5 million tons of coffee beans. We will write all of this in mathematical terms so the problem will look like the following:

$$
\begin{aligned}
\min_{Q,P} \quad & Q \cdot P = q_1 \cdot p_1 \; + q_2 \cdot p_2 + ... \\
\text{s.t.} \quad & \sum_{q \in Q} q \cdot 66 \cdot 0.45 = 1500000 \\
& Q \leq Max\_Capacity \\
& Q \geq 0
\end{aligned}
$$

In this problem (1) Q is a column vector of quantities of container imported through each of the available docks while P is a vector of corresponding prices of each container for each dock. The first constraint defines that we have to import exactly 1.5 million tons. Whilst others take into account maximum through-puts of docks along with solutions being positive to make sense.

After solving this problem we get the result written as real numbers with floating points. In real life we cant have a decimal number of containers, therefore, Antwerp optimal quantity should be increased to 3006 to meet the requirement of imports. In the end, we have the following solution in whole numbers:

	optimal quantity
Algeciras	20000
Amsterdam	0
Antwerp	3006
Genoa	7500
Hamburg	0
Marseille	9000
Rotterdam	0
Valencia	11000

Table 2: Optimal solution to problem 2

Such solution will result in least possible total costs of approximately **16.392.820 €**

3.3 Problem 3

The following docks (3) have a sign-up fee. This means that, if Beanie Limited wants to do any business with them at all, they need to pay this fee. This fee is only paid once and is independent of the container volume that goes through the dock.

dock	**Sign-up fee €**
Antwerp	1.000000
Marseille	500.000
Algeciras	800.000

Table 3: Signup fees

These signup fees might make previously optimal choices of docks unoptimal considering one-time signup fee. Therefore, we should remodel our problem, so that it takes into account such fees. Also, we will account for number maximum number of docks. You stated that we should not go over 3.

$$
\begin{aligned}
\min_{Q,P} \quad & Q \cdot P + A \cdot 1 = quantity_1 \cdot price_1 + sign\_up_1 \cdot is\_used_1 \ ... \\
\text{s.t.} \quad & \sum_{q \in Q} q \cdot 66 \cdot 0.45 = 1500000 \\
& Q \leq Max\_Capacity \cdot A \\
& \sum_{a \in A} a \leq 3 \\
& Q \geq 0
\end{aligned}
$$

In this setup of the problem everything is pretty much the same as in the previous problem (1) but we have sign-up fees and condition allowing only usage of up to 3 docks. If we solve this problem, we get the following:

	optimal solution
Algeciras	20000
Amsterdam	0
Antwerp	0
Genoa	0
Hamburg	0
Marseille	0
Rotterdam	19506
Valencia	11000

Table 4: Optimal solution to problem 3

Such solution will cost us **18.177.820 €**. Limiting ourselves to only use up to 3 docks results in higher total costs. It might seem logical to limit our network to only 3 docks to make the logistics simpler but still if the amount we save by using 5 docks as in previous case (2) instead of 3 is greater than additional costs coming from additional management and transportation costs of more complex logistics network, then we should definitely go for solution with 5 docks, otherwise this solution (4) is optimal.

3.4 Problem 4

As a result of potential increase in taxes prices might rise for imports through Valencia and Algeciras. You gave us a range for the prices where each price is equally likely, meaning both of them follow uniform distribution on their respective intervals.

$$Valencia\_price \sim U[310, 390]$$
$$Algeciras\_price \sim U[280, 330]$$

In order to analyse evolution of optimal solutions with such uncertainty we can use simulation, where we sample prices from these uniform distributions and solve optimisation problem (1) for each pair of sampled prices. This will allow us to calculate probabilities that given solution is optimal given pair of random prices. Also we will be able to find cost distributions for each unique optimal solution to pick one with most stable costs or ones with potentially lowest costs. Simulation will allow us to reframe such uncertainty in prices so that it is easier for us to choose a solution that best fits to the goals of the company.