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Case 2: Beanie Limited

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Dear Charles,

Having analyzed Beanie Limited's supply strategy for 2021, we think that there are some areas where operations can be improved. Below, we provide you with a more detailed explanation of our insights and recommendations.

1. 2021 strategy

With the data that you provided us for last year's performance, and data for this year's prices, we are confident that we can reduce the average cost per container. Last year you spent €13.700.000 on docks fees, and ordered 24.000 containers. Therefore, your average cost per container for 2021 was around €570. With the new prices for the different docks, we could reduce this average cost per container to €470 by ordering only from Rotterdam (assuming last year's demand).

Nevertheless, with the next year's estimation for demand of around 50.000 containers, there is no chance to reduce the total costs. Even if we used only the dock with the lowest price, which actually can't satisfy demand by itself, for every container, we would still have an increase in total costs. Given that it is not possible to reduce last year's total costs with the new volume, our goal will be to reduce the average cost per container for the next year.

2. Optimal strategy for 2022

Once we know the performance for last year can be improved, let's define a problem and solve it. With the information provided, a linear programming problem is the most suitable framework for solving this problem. These types of problems share the same features: decision variables, a target function and constraints.

- **Decision variables**

What are the variables whose values change the solution of this problem? In our case, the number of containers. Nevertheless, you might have noticed that those containers may come from different destinations, so we define a variable for each dock.

$$X_i : number\ of\ containers\ from\ dock\ i$$

where $i = 1, ..., 8$ (Rotterdam, Antwerp, Hamburg, Amsterdam, Marseille, Algeciras, Valencia, Genoa)

- **Target function**

Our goal is to improve the results of previous year in terms of cost per container. Thus, we minimize the cost per container of each dock and therefore the total cost.

- General version

$$Min \sum_{i=1}^{8} c_i X_i ,$$

where c_i: $cost\ per\ container\ of\ dock\ i$

- Extended version

$$Min\ 470X_1 + 470X_2 + 480X_3 + 610X_4 + 380X_5 + 280X_6 + 310X_7 + 340X_8$$

- **Constraints**

Obviously, this problem will make no sense if we could import all containers from the cheapest dock. However, we face limitations of capacity for each dock

$$X_i \leq Cap_i ,$$

where Cap_i: $capacity\ of\ dock\ i$

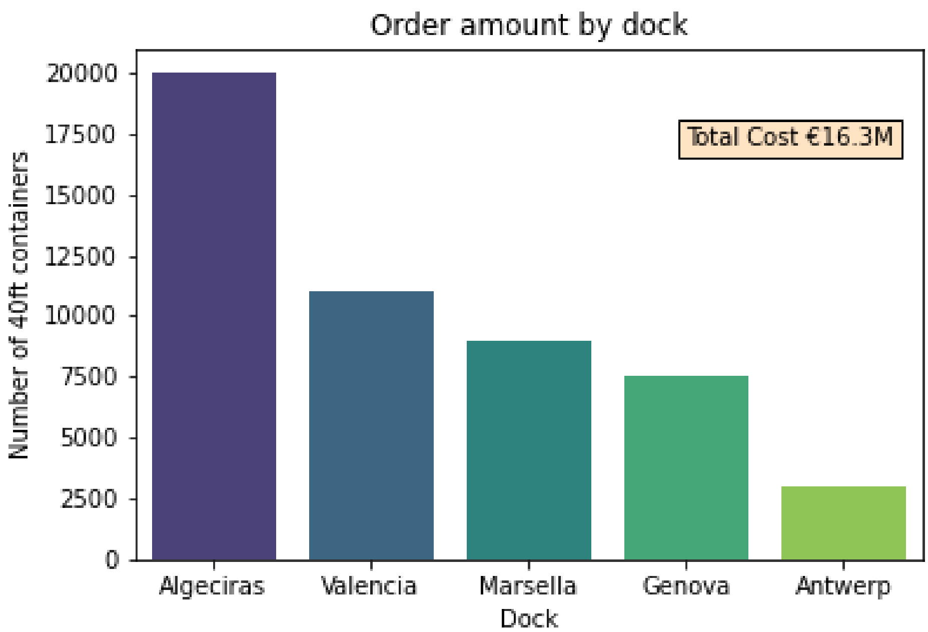
all the demand must be supplied,

$$\sum X_i = 50506$$

and non negativity for our decision variables.

$$X_i \geq 0$$

- **Results**



The optimal ordering strategy for 2022 would be to order 20,000 containers from Algeciras, 11,000 from Valencia, 9,000 from Marseille, 7,500 from Genova and 3,006 from Antwerp. The result from choosing this strategy would be a total cost of **€16,392,820**.

Comparing those results with the outcome achieved in the previous year, total cost has increased by **19%**. However, the total amount shipped has risen by **110%** and average cost has dropped by **43%**.

3. Optimal strategy for 2022 with maximum 3 docks and sign up fee

As you have mentioned, we deal with a new scenario in which there are sign up fees for some docks and limitations in the amount of docks where the containers can arrive. So, we integrate those issues in our linear programming model in order to provide you with an optimal solution.

- **Decisions variables**

To solve the problem, we use the same decision variables as in the previous request but now adding a dummy variable which helps us to satisfy your desire of only having three active docks. Therefore:

$$X_i: \textit{number of containers from dock } i$$

$$w_i: 1 \textit{ if Charles receives containers from dock } i.\ 0 \textit{ otherwise.}$$

where $i = 1, ..., 8$ (Rotterdam, Antwerp, Hamburg, Amsterdam, Marseille, Algeciras, Valencia, Genoa)

- **Target function**

Our goal is still minimizing the cost per container and total cost but taking into account the new restrictions.

- General version

$$Min \sum_{i=1}^{8} c_i X_i + f_i w_i \ ,$$

where c_i: *cost per container of dock i*

f_i: *sign up fee of dock i*

- Extended version

$$Min\ 470X_1 + 470X_2 + 480X_3 + 610X_4 + 380X_5 + 280X_6 + 310X_7 + 340X_8 \ +$$

$$+ \ 1,000,000w_2 \ 500,000w_5 + \ 800,000w_6$$

- **Constraints**

In this case, it is essential to modify constraints in order to reach the solution. Capacity limitations from each dock,

$$X_i \leq Cap_i x_i$$

where Cap_i: $capacity\ of\ dock\ i$

no more than three docks,

$$\sum w_i \leq 3$$

all the demand must be supplied,

$$\sum X_i = 50506$$

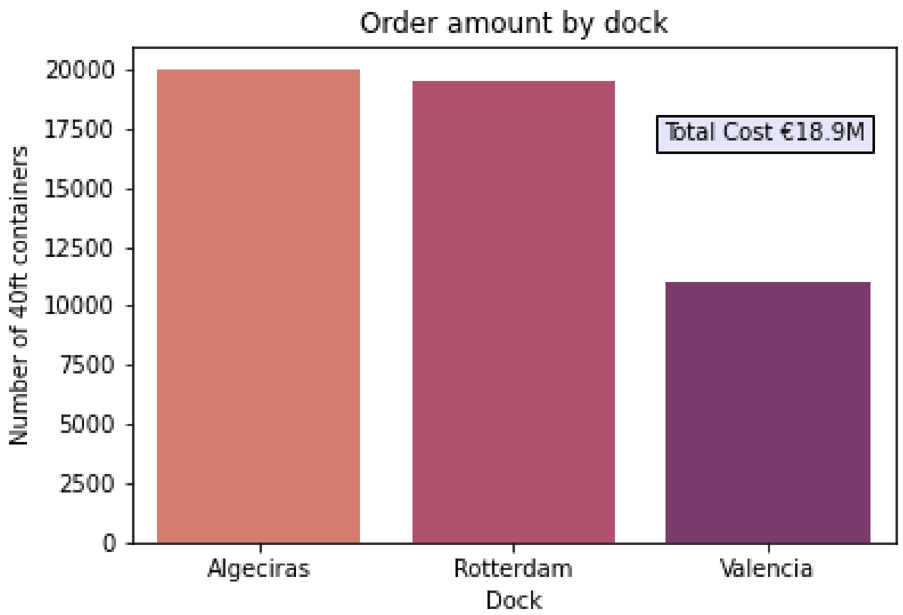
non negativity for our decision variables,

$$X_i \geq 0$$

and w_i binary

$$w_i\ binary$$

- **Results**



The optimal ordering strategy taking into account sign up fees, and a maximum of three docks would be to order 20,000 containers from Algeciras, 19,506 from Rotterdam and 11,000 from Valencia. This strategy would result in a total cost of **€18,977,820.**

If we take into account the sign up fees and use a maximum of three docks, the total cost would increase **15.76%**. These changes significantly change the strategy proposed previously, as different docks would be used and costs would increase.

Using the first strategy we proposed, the average cost per container would be **€324.57**. With the new restrictions in place, the average cost per container would be **€375.75**. This leads to an increase of **15%** of the average cost due to the new restrictions. Nevertheless, the new average cost is still **35%** cheaper compared with the initial strategy.

4. Policy proposal with uncertain prices

Given the uncertainty for next year's price for Valencia and Algeciras due to the new regulations, we would suggest to simulate the different possibilities and scenarios, and find an optimal strategy for each case.

We would do the following: use every possible price combination for Valencia and Algeciras in the interval you provided for us (using €1 steps) and find an optimal ordering strategy in each case.

With the price ranges for Valencia and Algeciras, we estimate that we would need to run 4000 simulations. What we expect to obtain from the simulation are the different ranges of prices for when it is convenient to order from these docks, and when it is not. We could also obtain worst and best case scenarios for both docks and what the total costs would be, and also the probability of having a scenario when ordering from these docks is not optimal. We think that with this information you could make a decision of whether it is worth it or not to order from these two docks.