

EXERCISE 1. NETWORK DESIGN

GreenC is a company with two plants, one in Porto, with a manufacturing capacity of 300 ton and another in Lisbon, with a capacity for 500 ton. The company identified four regions of demand that are Spain, France, Germany and United Kingdom. In order to fully supply these markets, the company wants to know how many distribution centers it should have and where to locate them, having three different possible locations: Paris, Berlin and London. In figure 1 the supply chain network is represented.



Figure 1 – Supply chain network.

As this supply chain operates at European level, it is subject to different kinds of uncertainty. The company wants to take into account this aspect considering the uncertainty in the products' demand, using two scenarios: pessimistic (1) and expected (2) demand. The probabilities of occurrence of each scenario are, respectively, 30% and 70%. In table 1 the values for the demand of each market for each scenario are listed.

Table 1 – Demand in the different markets, for each scenario.

Ton	Spain	France	Germany	U.K.
Scenario 1	50	75	100	75
Scenario 2	100	150	200	150

The capacities of each distribution center and the fixed costs associated with their installation are presented in table 2. These infrastructures receive the products and immediately send them to the markets, they do not keep inventory.

Table 2 – Distribution centers data.

Distribution Center	Capacity (ton)	Fixed Cost (€)
Paris	500	2000
Berlin	300	2000
London	350	1900

The unitary transportation cost between all entities is 0.5€/ton.km. The distances from the plants to the distribution centers are presented in table 3 and from the distribution centers to the markets are in table 4.

Table 3 – Distances between plants and DC's in km.

	Paris	Berlin	London
Porto	1583	2632	1941
Lisbon	1738	2787	2096

Table 4 – Distances between DC's and markets in km.

	Spain	France	Germany	U. Kingdom
Paris	1268	0	784	526
Berlin	2314	1358	0	1195
London	1869	948	1017	0

Please answer the questions provided below. In your practical report do not forget to critically comment all your answer, explaining the modeling and implementation phase and subsequent results.

- Considering the network design modelling problem, do a brief literature review (300 words approximately). You can give examples of different scientific approaches to the problem, as well as mathematical model formulation you found interesting. It is also valued that you highlighted the main streams of investigation followed by researchers nowadays. Insert your search in the "Methodology section" of your report.
- Based on the practical classes, develop a mathematical model that can optimize the network design of the supply chain while minimizing the costs (identify parameters, variables, binary variables, objective function and constraints).
- Implement the developed model in *Excel* and determine the number and location of the distribution centers and the flows that should be established between all entities of the supply

chain, in order to minimize the total costs.

- d) What other aspects should be considered in the objective function I? Justify your answer.
- e) To better understand the impact of the different parameters involved in the exercise, please answer the following questions considering the following information. Due to COVID-19 pandemic the market suffers several changes and companies needed to adopt their businesses and struggle to fulfil their customer needs. Considering the following three scenarios, comment the changes that occur in the distribution network:
- I. The demand of the German market increases 50% in both scenarios.
 - II. Given the high demand for transportation services and the scarce number of providers operating, the transportation cost tripled.
 - III. Due to real estate speculation, the land price in Paris increased substantially, namely for the same selling price just 1/5 of the capacity could be acquired. Assume that GreenC has budget limitations and cannot spend more than the 2000€ on a site.
- f) The design and adoption of sustainability strategies throughout business operations has emerged as a meaningful intervention to accommodate future challenges such as economic crises, social exclusion, and climate changes, with direct impact upon business activities. In the contemporary global contextual framework, sustainability transcends the environmental dimension and further relates to an economic and social perspective. How can Green C design its network to pursue a more sustainable supply chain?