Supply Chain Analytics (42380)
Assignment 2

Hand-in date	Tuesday 18 April at 22:00. Same groups as in Assignmnent 1. One hand-in per group.
Hand-in format	Detailed report in PDF addressing all questions thoroughly, plus the corresponding Julia and Excel files. The report should be self-contained and explanatory (including graphs, figures, tables, etc.) without the supplementary files and have a maximum length of 8 pages. The Excel and Julia files are used for checking, documenting, and reproducing the calculations.

Your boss at *Indiana Jeans* has seen potential in you and wants to involve you in the upcoming decision that the company needs to make.

Part 1: Network design

Indiana Jeans is expanding in the European market and seeking to open manufacturing plants and distribution centers (DCs) to serve new customers. The location of the potential and existing manufacturing plants and distribution centers as well as their capacities, are given in the attached spreadsheet `Assignment2_Data.xlsx` and are also depicted in Figure 1. The spreadsheet also includes the location of the customers and their demand.

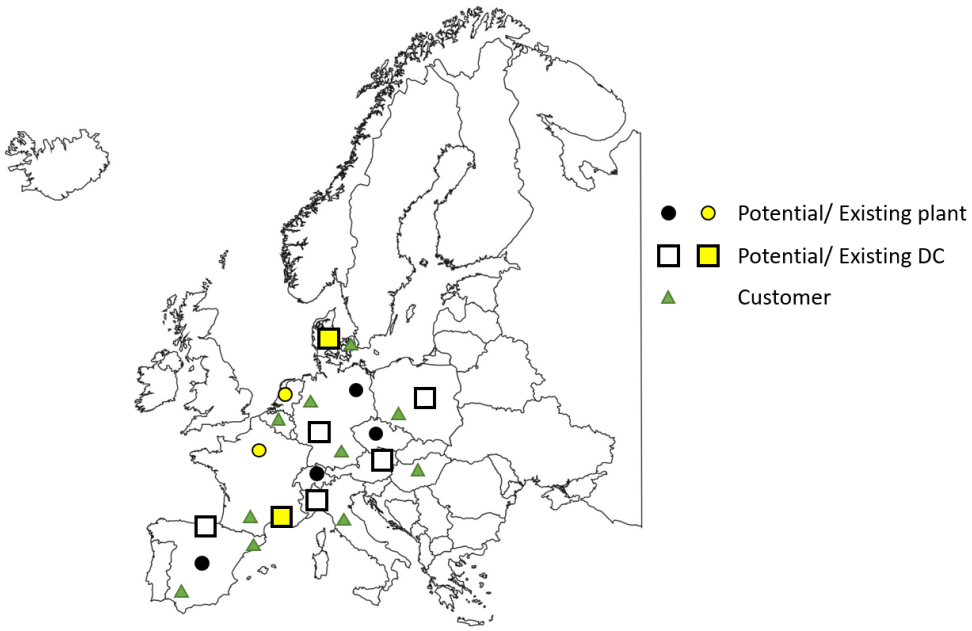

Figure 1

Assumptions:

- *A customer can only be served from a DC and not from a plant.*
- *The transportation costs between locations are proportional to the euclidean distance. We can assume that a straight road exists between each pair of locations, and the units are kilometers. The cost of transporting one unit between a DC and a customer is 0.2 $, whereas this cost between a plant and a DC is cut in half.*

1. Write the mathematical formulation of a network design problem that jointly optimizes the location of manufacturing plants, distribution centers, and allocation of customers. Describe the set of variables and parameters, the objective function, and the constraints.

2. Write and solve the model in Julia.

3. You are asked to report the solution to your boss and the rest of the team. Most of the team do not have a *math* background, so describe the solution in a popular way (limiting the mathematical terms as much as possible and considering a supporting figure or table).

4. Give an assessment of the proposed solution. Are all plants and distribution centers being used at full capacity? Assuming that any plant can get disrupted with equal probability, which DCs are in a riskier position and why?

5. The company also considered not opening any new production plants and instead expanding the capacity of the existing ones. The investment needed for doubling the capacity of each of the plants is 1.5 million $. Formulate and solve the problem with this new setup and compare the total costs. Which option is more economical?

Part 2: Distribution planning

The company has been using direct shipping between the DC and the shops in Denmark since its foundation. The drivers are used to the same simple route back and forth from the DC to the shop. You look at the size of the shipments each of the shops is ordering and immediately realize there is a lot of room for improvement. In this case, we limit our study to 15 shops served by the DC in Aarhus. The second tab in the spreadsheet contains the distances between all the shops and the DC, and their demand. Each truck has a capacity of 80.

Considering that all the shops order simultaneously and for a single period, optimize the truck routes to minimize transportation costs.

Assumptions:

- *The DC is seen as the depot, and all vehicles depart and end their route at it.*
- *Each route is driven by a different vehicle.*
- *Each vehicle is driven by a different driver.*
- *The transportation costs are directly proportional to the distance (1 $ per km) and independent of the truckload.*

1. Solve the problem using the Clarke-Wright heuristic and report the set of routes and the total transportation costs.

2. Assuming there are some fixed costs of 200 $ associated with paying each driver to operate a route, which total savings can the company achieve with the new set of routes?

3. Formulate the mathematical problem in Julia, including the fixed costs, and solve it using a commercial solver. Report the optimal solution and compare it to the one found with the heuristic method. If you use a time limit, report the best-found solution. What would be the variation in the cost of this solution if we assume that transport costs are load-dependent (0.1 $ per unit and km)?

4. The company is considering acquiring a new fleet of electric vehicles. These vehicles have lower transportation costs (0.5 $ per km), but a capacity of 50. Resolve the model only considering this type of vehicle and compare the operational costs in terms of total transportation costs and distance.

5. Finally, to make a more realistic analysis of the electric fleet implementation, we need to consider the vehicle's autonomy and the current truck fleet. Each vehicle can run for 500 km before needing to rechargie, and at most, five electric vehicles will be available. Incorporate these restrictions into the model and compare the solution to the previous two scenarios, with only trucks, and only new electric vehicles.