Beer Transportation Game[1]

Background

A Belgian-based brewer has a large distribution center (DC) in London to serve the UK market, which is replenished directly from the brewery in Brussels (Belgium) (Figure 1). The UK market is highly competitive with uncertain customer demand that can wildly fluctuate from day to day. An unsatisfied customer demand is costly because it deteriorates the brewer's reputation in customer service, and potentially offers its market share to its competitors. The brewer therefore keeps inventory at the DC to buffer the fluctuating demand from the customers.

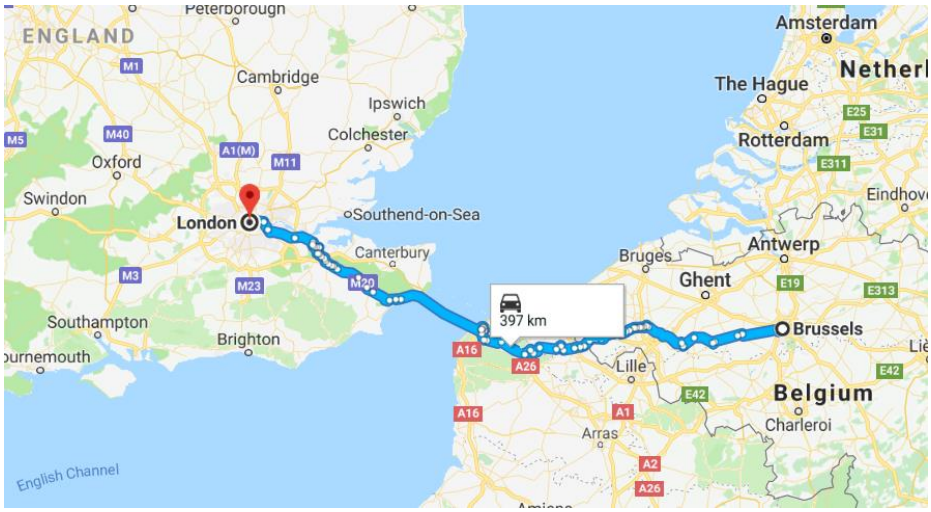

Figure 1: On an annual basis about 3,300 full container loads of beer are shipped from the brewery in Brussels to the distribution center in London.

Currently, the brewer replenishes its London DC using daily truck shipments from Brussels. The prime reason for direct trucking is the flexibility to deliver any volume as required at short notices. An order placed at Brussels before 14:00 will be shipped overnight and delivered to London before 10:00 in the next morning. The freight is transported and measured in full container loads (FCLs), the standard shipment unit of the industry. One truck carries exactly one FCL. It can be assumed that one FCL loads on average 10 tons (10,000 liters) of beer, and 14 tons of packages (including the container itself). The payload (the total weight of a fully loaded container) of one FCL is therefore 10 + 14 = 24 tons.

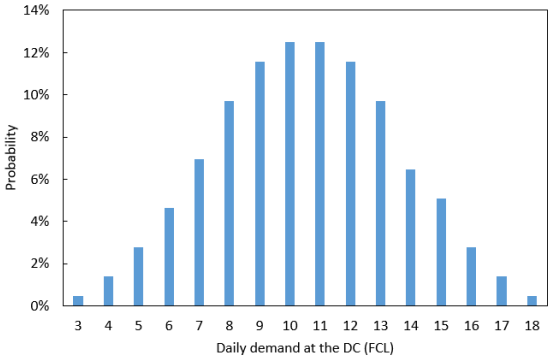

Figure 2: The probability distribution of the daily demand measured in FCL at the London DC.

The daily demand at the DC (measured in FCL) is random, but the random distribution does not vary from day to day. Figure 2 shows the

[1] Chuanwen Dong and Robert Boute wrote this game solely to provide material for class discussion. The authors do not intend to illustrate either effective or ineffective handling of a managerial situation.

distribution of daily demand: It ranges between 3 and 18 FCLs with a mean of 10.5 and a standard deviation of 3. The DC operates from Monday to Saturday every week, and hen ships about 3300 FCLs from Brussels to London every year.

Rail: the more sustainable transport mode

As the logistics manager of the brewer, you are aware that rail transport is more sustainable and want to decarbonize logistics by moving freight from road to rail. Luckily, both the brewery and the distribution center are located close to rail terminals. Moving freight from road to rail would require almost no additional operational effort, since the beer is well packed and sealed in containers, and the modal shift hence simply means transporting the same containers using rail wagons instead of truck trailers.

You start by collecting data so that the impact of your logistics decarbonization plan will be well evaluated.

Road transport emits on average 75g CO_2 per tonne-kilometre (TKM) (European Environment Agency 2013). The distance from Brussels to London is about 400 kilometers, so shipping one FCL emits 400×24×75 = 720,000g, or 0.72 tons of CO_2. Rail transport discharges only 21g CO_2 per tonne-kilometre (TKM) (European Environment Agency 2013), hence it emits only 400×24×21 = 201,600g, or 0.20 tons of CO_2, to deliver the same FCL from Brussels to London. If you could move the annual freight (3300FCLs) from road to rail, you would be able to save about (0.72-0.2) ×3300 = 1716 tons of CO_2 every year, equivalent to the annual emissions from about 800 UK households[2].

Much to your delight, you find that rail transport is not only greener, but also cheaper (provided some conditions are met). The average trucking cost is one EUR per kilometer, so that it costs 400 EUR to transport one FCL from Brussels to London. The rail operator can offer you a lower price, however, subject to a volume commitment. Because management of rail fleet and the plan of train schedules are much less flexible than those of road transport, the rail operator requires you to commit a stable volume in order to benefit from the lower price, e.g., always shipping five FCLs every time the train operates. This way, the rail operator is able to better manage its capacity and can offer you a price of 350 EUR per FCL shipment. In addition, the train from Brussels to London only operates on Monday, Wednesday, and Friday. Delivery times are similar to road transport: an order placed before 14:00 will be shipped overnight and delivered in London before 10:00 the next morning.

Inventory management and total logistics cost

You realize that the rigidity of rail transport might impact the inventory at the DC. A so-called “base-stock policy", which is straightforward and widely implemented in the industry, is currently applied at the DC. It works with a predefined “base-stock” level, say X, as a benchmark. At 14:00 each day, after customer demand is satisfied from the inventory at the DC, you record

[2] According to World Energy Council (2014), a household in the UK emits on average 2.12 tons of CO_2 per year.

the leftover inventory, say Y, and order the difference, X-Y, from the brewery. This difference will then be transported overnight from Brussels to London. At 10:00 the next day, you will have X inventory again at the DC, which can be used to satisfy the demand of that day. Note, if the inventory exceeds the base-stock level, i.e., Y>X, then no replenishment order is placed.

Obviously, you want to limit the amount of inventory held at the DC and thus does not want to set the base-stock level X too high. After all, keeping inventory is costly for the firm. The "rule of thumb" is that the average shelf-life of the beer is one year and the annual inventory cost (including the cost of warehousing, the cost of inventory write-off, etc.) is 100% of the product value. Assuming that the beer costs 5 EUR per liter, the daily inventory holding cost of a 10,000 liter FCL is then 5×10,000×100%/365 = 136 EUR. In case there is insufficient inventory in the DC to meet an unexpected large customer demand, an inventory stock-out is registered with a penalty cost. This situation is especially costly because it not only induces a loss of sales, but also hurts a firm's reputation in customer service. The brewer guarantees a 95% in-stock probability to its customers, which corresponds to a unit stock-out penalty cost of 2584 EUR per FCL per day[3]. Both the inventory holding and stock-out penalty costs are recorded to evaluate your performance. Table 1 summarizes the parameters in the game.

Table 1: A list of parameters used in the game

Description	Value	Unit
Shipping cost via road transport	400	EUR per FCL
Shipping cost via rail transport	350	EUR per FCL
Carbon emissions of road transport	0.72	ton per FCL shipment
Carbon emissions of rail transport	0.20	ton per FCL shipment
Unit inventory holding cost at the DC	136	EUR per FCL per day
Unit inventory stock-out penalty cost	2584	EUR per FCL per day
Mean of daily demand at the DC	10.5	FCL
Standard deviation of daily demand	3	FCL

Since the change of transport mode might impact the inventory management at the DC, you should naturally evaluate the total logistics costs, including both transport and inventory costs. For simplicity reasons, you can ignore the emissions from warehousing, since the storage of beer at the DC does not require cooling systems and the corresponding emissions, compared to those from transport, are only marginal.

Your task

You should make transportation mode decisions: Ship the volume from Brussels to London using road trips every day, or alternatively, use a train that operates on Monday, Wednesday, and Friday. Road transport can ship any flexible volume and rail transport requires the same fixed quantity in every delivery. Your decision will be evaluated by the total logistics cost and emissions.

[3] The in-stock probability is given by the critical newsvendor fractile (unit holding cost)/(unit holding cost + unit stock-out penalty cost). Interested students could read any standard textbook covering inventory fundamentals for more information.