Practical 2
Demand monitoring, part I

In this second practical, we will look at product sales data belonging to a large American retailer. As the person in charge of re-stocking products after they are sold, you would like to avoid a ‘stock-out’, that is, when on a given day there are not enough products to satisfy customer demand.

Consider the observations recorded in `sales_1.txt`, which contain the daily sales volumes of Product 1 over $n = 1913$ days.

(a) Construct a figure which shows the daily sales volume, and study the values just before the product is out of stock. What do you notice? Explain why this is related to stock-out.

(b) Assume Product 1 is a perishable good sold at a constant price of 10.– over the time period considered. Items of Product 1 are produced at cost 1.– and items which are unsold can be salvaged at 10% of cost, that is, at value $s = 10$ ct. Suppose that the sales of Product 1 are distributed according to F. Using the newsvendor model, give a formula for the critical fractile $q = F^{-1}(p)$.

(c) Explain how the critical fractile is related to the Value at Risk, and give an interpretation of the Expected Shortfall at the level p.

(d) Fit a Poisson model to the sales volume data by assuming that $Y_i \overset{iid}{\sim} \text{Poisson}(\mu)$ and using maximum likelihood estimation for μ. *(Hint: you may use `MASS::fitdistr`).* According to this model, what is the estimated critical fractile?

(e) Suppose we model the sales as an extreme value distribution using a peaks-over-thresholds method. Give the Value at Risk at level p under this model.

(f) Perform a binomial back-test over the last 300 days in the dataset for the models in d) and e), using a window size of 365 days. What are your conclusions?