Stochastic Decision Theory (2MMS50)

Assignment Part IV, to be completed Wednesday, July 20, 2022

Please provide brief but careful motivations of your answers.

The Netherlands is facing the challenges of making sure that there is enough natural gas for 2023. The annual demand for gas is determined to be uniformly distributed between 38 and 44 billion (10^9) cubic meters per year. The government has the option to buy gas on the current market at a rate of 50 cents per cubic meter. If not enough gas is bought, it is possible to buy this at a later date, for a price of 1 euro per cubic meter. Gas that cannut be used immediately has to be stored, which costs 10 cents per cubic meter.

a) Determine how much gas needs to be bought in advance by formulating and solving a newsvendor problem.

b) There is disagreement on the exact distribution of energy demand, as the uniform distribution in a) is fitted based on two moments. Find a more robust order quantity based on these two moments.

c) There is a third option to buy energy, at an intermediate market, in september, at which point gas will be 75 cents per cubic meter. The demand uncertainty in september will be unniformly distributed in an interval $[A, B]$, where (A, B) are respectively the minimum and maximum values of (U_1, U_2), with U_i uniform on $[38, 44]$. Formulate this problem as a two-stage stochastic optimization problem and use the sample average approximation method to develop a solution. Do this for $N = 100, 200, 300$ scenarios.

d) The Netherlands has the option to build a storage unit which can hold 3 billion cubic meters of gas, gas stored in this device is free. How much is this option worth under the setting of c)? You may again use the sample average approximation method for developing an answer.