Little Barbie Purchasing Problem

An illustration of basic game theory and supply chain coordination concepts

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You are the manager of the retail store "Toys and Co" and you are concerned with the inventory management of your star product "Little Barbie". The demand for this product is mainly concentrated during the selling period before Christmas, i.e. November and December. This demand is not known exactly in advance but could be estimated thanks to last year sales as provided in the following table:

Demand Value	Probaility
40	0.009
45	0.014
50	0.019
55	0.024
60	0.029
65	0.034
70	0.039
75	0.044
80	0.049
85	0.054
90	0.059
95	0.064
100	0.069
105	0.068
110	0.063
115	0.058
120	0.053
125	0.048
130	0.043
135	0.038
140	0.033
145	0.028
150	0.023
155	0.018
160	0.013
165	0.007

Little Barbie is Manufactured is in a low cost and far away country. As a consequence, you have only one opportunity to replenish in March. So, you have to order the right quantity in March which is delivered to you just before the selling season in November.

The production cost for each item is denoted by c and is equal to c = 10 euros. During the selling season, you earn a comfortable margin by setting the selling price denoted by r equal to r = 50 euros. At the end of December, unsold and remaining items in your stock should be discounted during the

sales period of January. The discount price denoted by s is given by s = 5 euros.
Your aim in this decision making process is to find the best quantity to order, denoted by Q, which maximise your expected profit.

The Centralized case:

We consider in this centralized case that the manufacturing site in the low cost country belongs to your retail store and we assume that there is no margin applied between the production and the retailing site.
1. Calculate the unit penalty incurred when a shortage occurs during the selling season as well as the unit penalty associated with an unsold item.
2. From an intuitive point of view, do you have to order a quantity lower or higher than the demand average?
3. For a given vector (Demand D, ordered quantity Q), express the profit you make during the selling period. Apply for the different demand values to calculate the expected profit.
4. Using python basics (list, function), derive the optimal ordering quantity

The decentralized case with a Take-it-Or-leave-it contract

We consider now that your supplier is an independent firm and makes a margin when producing and selling "Little Barbie" to your retail store. His unit production cost is c = 10 euros and his wholesale price is denoted as w.
He is aware of the market facing you, so he has an information about your demand, and he proposes to you a take it or leave it contract where he fixes the wholesale price w. You, based on the price w, you optimize your inventory strategy and your order a quantity Q maximizing your profit.
When proposing you the wholesale price w, the aim of your supplier is naturally to maximize his own expected profit.
1. If you were the supplier, what would be your optimal proposed wholesale price w.
2. Calculate the total profit of the decentralized case (you + your supplier) and compare it with the centralized profit

The decentralized case with a coordination contract

The aim is to build a coordination contract permitting to increase the total supply chain profit to let it equal to the centralized case.
1. What type of coordination contract do you recommend to achieve this target?