Solving the Newsboy Problem

Often managers have to make decisions about inventory level over a very limited period. This is the case, for example with seasonal goods such as Christmas cards that should satisfy all demand in December, but any cards left in January have almost no value. These single-period decision models are phrased as the Newsboy Problem. For a newsboy who sells papers on a street corner, the demand is uncertain, and the newsboy must decide how many papers to buy from his supplier. If he buys too many papers he is left with unsold papers that have no value at the end of the day; if he buys too few papers he has lost the opportunity of making a higher profit.

To demonstrate how to solve a typical newsboy problem with continuous demand, we formulate a problem. Let us suppose that demand for the papers are normally distributed with mean of 500 papers and standard deviation of 100 papers. If each paper costs the newsboy 10 cents and he sells a paper for 30 cents, how many papers should he order each day? [For now, we assume that he cannot resell unsold papers back to the supplier.]

If he sells a paper, the newsboy makes a profit of 20 cents. If not, he loses 10 cents. Thus, if he orders x papers, his expected return on the i\textsuperscript{th} newspaper is given by E(profit\textsubscript{i}) = 20p – 10(1 – p), where p is the probability he sells the i\textsuperscript{th} paper. Breakeven occurs where E(profit\textsubscript{i}) = 0.

Now to find the probability of selling the i\textsuperscript{th} paper we use what we know about the distribution of sales. From the diagram below, we see that the probability of selling the i\textsuperscript{th} unit = P(X > i), which is the area under the curve to the right of x.

![Newsboy Problem Marginal Profit Diagram]
So, if we know the z-score for x, we can use our normal distribution table to find the area, or, conversely, if we know the z-score, z* we can find the x* for the breakeven unit. In our case, we solve for the breakeven p* as follows: 20p* - 10(1-p*) = 0 => 30p* = 10, or p* = 1/3. From the normal table we find that z* = .431. Then we solve the following equation: .431 = (x* - μ)/σ = (x* - 500)/100. Thus, x* = 43.1 + 500 = 543 papers.

Now suppose we can resell the unsold papers back to the distributor for 5 cents each. Then our breakeven equation becomes 20p - 5(1 - p) = 0. In general, if MR = marginal return and ML = marginal loss on unsold units, we solve the equation MR*p - (1-p)ML = 0. This gives p(MR + ML) = ML, or p* = ML/(MR + ML). In the case that the newsboy can sell back the papers for 5 cents we get p = 5/(20 + 5) = .2 and z* = .842, so x* = 584 papers.