

The Division of Highways (DH) is considering expanding a 30-mile stretch of the Santa Renta freeway. The freeway is currently 2 lanes in each direction and is fully capable of carrying its current load of traffic. However, the load is apt to increase appreciably during the next several years. The DH knows from experience that if a freeway is to be expanded, it should be done before the heavy load of traffic, which the expanded freeway is designed for, materializes. This is because the capacity of a freeway is diminished while the freeway is being expanded, and the resulting congestion causes severe public inconvenience.

Emmy Biay, Director of the DH, takes the approach of assessing the likelihood of various possible eventual levels of traffic demand on a given freeway. Such levels are measured in terms of lanes needed in each direction. Using demographic studies and other means, these probabilities have been determined for the Santa Renta freeway and are shown below:

Eventual Demand on Santa Renta Freeway

<i>Lanes Needed</i>	<i>Probability</i>
2 or less	0.2
3	0.2
4	0.4
5	0.2

Thus, the DH is quite uncertain about how many lanes will eventually be needed. The one thing they are certain about is that they must satisfy the eventual demand with a freeway of sufficient capacity. For example, if demand eventually turns out to be the equivalent to 5 lanes (in each direction), then the freeway must be expanded to 5 lanes. In five years, the exact number of lanes needed will become known with certainty. Thus, the DH must decide whether to increase the capacity of the freeway now, and, if so, how many lanes to add. In five years, when eventual demand becomes known, the additional lanes needed, if any, must be constructed. They have decided to either build now or wait for five years and build, if necessary, after the eventual demand is known. If they "wait and see," building only enough lanes as are needed and the eventual demand is heavy, this entails considerable congestion. In addition, construction costs will be higher later, even when discounted back into present, 2009 dollars at a discount rate of 10%. These future (2014) costs are shown below:

*Costs to Build Later
(M=million)*

<i>Additional Lanes Added</i>	<i>Cost (\$M, discounted to 2009)</i>
1	60
2	100
3	120

Costs to build now are somewhat lower. However, by expanding now, the DH runs the risk of adding too many lanes or of still having to add another lane or two later on. For example, if the DH expands to 3 lanes now, and if eventual demand remains at 2 lanes or less, the money would have been wasted. However, if eventual demand becomes 4 lanes, then another lane would have to be added later, resulting in additional cost and congestion.

Current construction costs are shown below.

Costs to Build Now

<i>Capacity (Lanes)</i>	<i>No. Lanes Added</i>	<i>(\$M, 2009)</i>
2	0	0
3	1	40
4	2	60
5	3	80

Biay had previously established a method for estimating the dollar costs associated with congestion, so that this important factor could be considered directly in her office's analyses. These costs include congestion costs, during the next five years, and the congestion costs associated with subsequent construction, if needed. No congestion costs are incurred for building which takes place now. The congestion costs are shown below:

Public Costs Due to Congestion (\$M, 2009)

<i>Eventual Demand (Lanes Needed)</i>	<i>Capacity (Lanes) After Any Construction Done Now</i>			
	2	3	4	5
<i>2 or less</i>	0	0	0	0
<i>3</i>	10	0	0	0
<i>4</i>	20	10	0	0
<i>5</i>	30	20	10	0

For example, if the DH expands to 3 lanes now, and 4 lanes are eventually needed, then the costs (in millions of 2009 dollars) may be computed as follows:

$$\begin{aligned} & \text{(current construction cost, expand to 3 lanes now)} + \text{(congestion cost, 3 lane capacity now and 4 lanes} \\ & \text{needed)} + \text{(present value of later construction cost, add one lane to expand to 4 lanes later)} \\ & = 40 + 10 + 60 = \$110\text{M.} \end{aligned}$$

The four alternative actions which the DH faces are "no expansion until eventual demand is known" or "expansion now to either 3, 4, or 5 lanes".

- a) Construct a payoff table for this problem containing the cost for each decision in 2009 dollars, corresponding to each possible outcome.
- b) If the DH were willing to decide based on expected costs, which alternative should it choose?
- c) What is the expected value of the regret for each alternative?