IE5203 Decision Analysis
Solutions to Chapter 8 Case Study Exercise (Biotekno)

Decision Basis Development

Decision Variables

1. Partnership?
   a) No partner
   b) Joint venture Partnership
   c) Royalty partnership

2. Build new plant?
   a) Build new plant
   b) Don't build new plant

Business Strategies

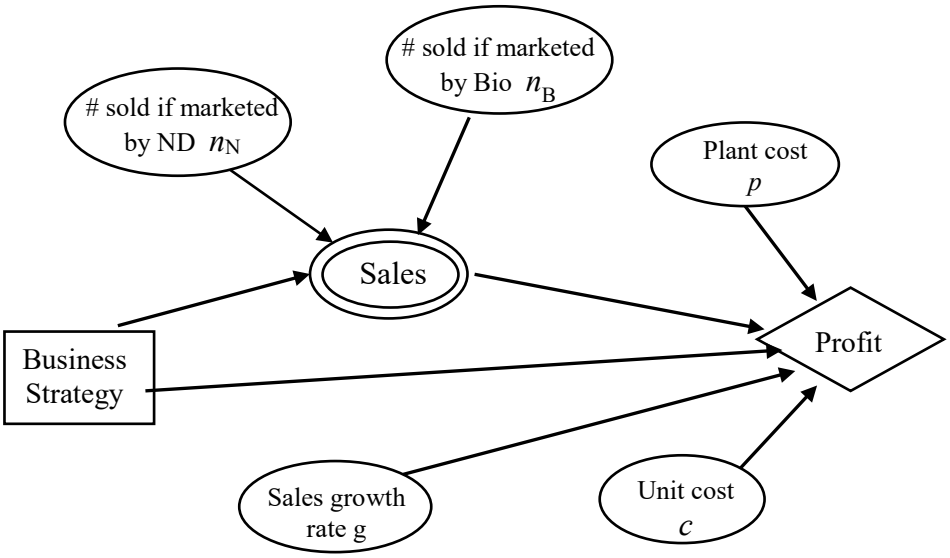
I. No partner, build new plant
II. No partner, don't build new plant
III. Joint venture partner, build new plant
IV. Royalty partnership, don't build new plant

Uncertain Variables

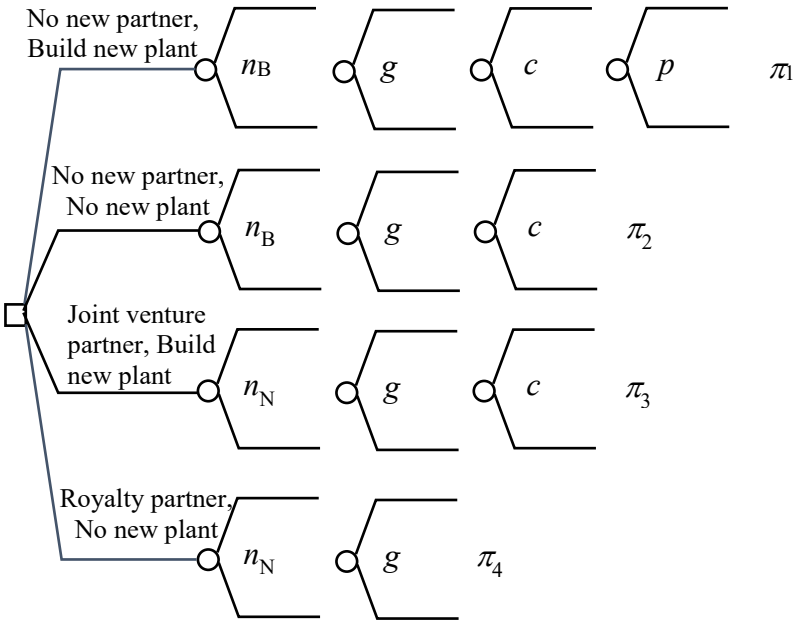
- n_B: number of units sold, if marketed by Biotekno (million)
- n_N: number of units sold, if marketed by National Diagnostics (million)
- g: annual growth rate, %.
- c: cost of production (million $)
- p: plant cost (million $)

Decision Diagram and Tree

Influence Diagram



The Generic Decision Tree



Value (Business) Models

Alternative I: No partner, Build new plant:

$$\begin{aligned}\pi_1 &= (20-c)[n_B + n_B(1+g)] - p \\ &= (20-c)n_B(2+g) - p\end{aligned}$$

Alternative II: No partner, No new plant:

$$\pi_2 = (20-c)[\min(n_B,4) + \min((1+g)n_B,4)]$$

Alternative III: Joint venture partner, Build new plant:

$$\begin{aligned}\pi_3 &= 0.5(20-c)[n_N + n_N(1+g)] \\ &= 0.5(20-c)n_N(2+g)\end{aligned}$$

Alternative IV: Royalty partner, No new plant:

$$\begin{aligned}\pi_4 &= 0.02(20)[n_N + n_N(1+g)] \\ &= 0.02(20)n_N(2+g)\end{aligned}$$

Deterministic Structuring

Deterministic Base Case Analysis

- The base values for all the variables are:

Variables	Symbol	Base Value
Plant construction cost (million $)	p	15
Sales growth rate (%)	g	20
Sales, 1st year, Biotekno (million $)	n_B	3
Sales, 1st year, National Diagnostics (million $)	n_N	4
Unit production cost ($)	c	9

- The 2-year profit for the four alternatives are:

Alternative		**2-year profit ($million)**
I	No partner, new plant	57.600
II	No partner, no plant	72.600
III	Joint venture partner, new plant	48.400
IV	Royalty partner, no plant	3.520

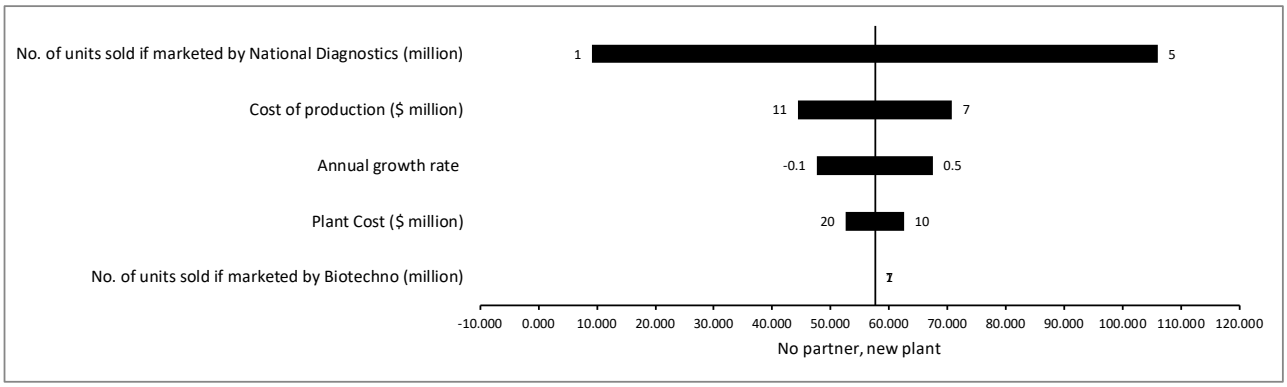
One-Way Range Sensitivity Analysis

- The low, base, and high values based on 5, 50, and 95 percentiles are:

Variables	**Symbol**	**Low**	**Base**	**High**
Plant construction cost (million $)	p	10	15	20
Sales growth rate (%)	g	-10	20	50
Sales, 1st year, Biotekno (million $)	n_B	1	3	5
Sales, 1st year, National Diagnostics (million $)	n_N	1	4	7
Unit production cost ($)	c	7	9	11

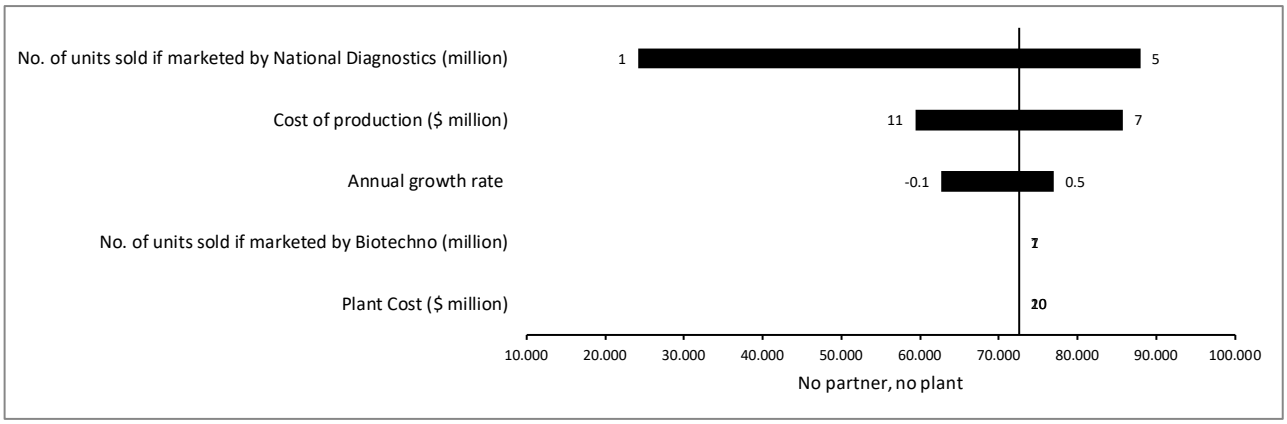
Alternative I: No partner, Build new plant

	Input Variables			No partner, Build new plant			
Variable	Low	Base	High	Low	Base	High	Swing
n_B	1	3	5	9.200	57.600	106.000	**96.800**
c	11	9	7	44.400	57.600	70.800	26.400
g	-0.1	0.2	0.5	47.700	57.600	67.500	19.800
p	20	15	10	52.600	57.600	62.600	10.000
n_N	1	4	7	57.600	57.600	57.600	0.000



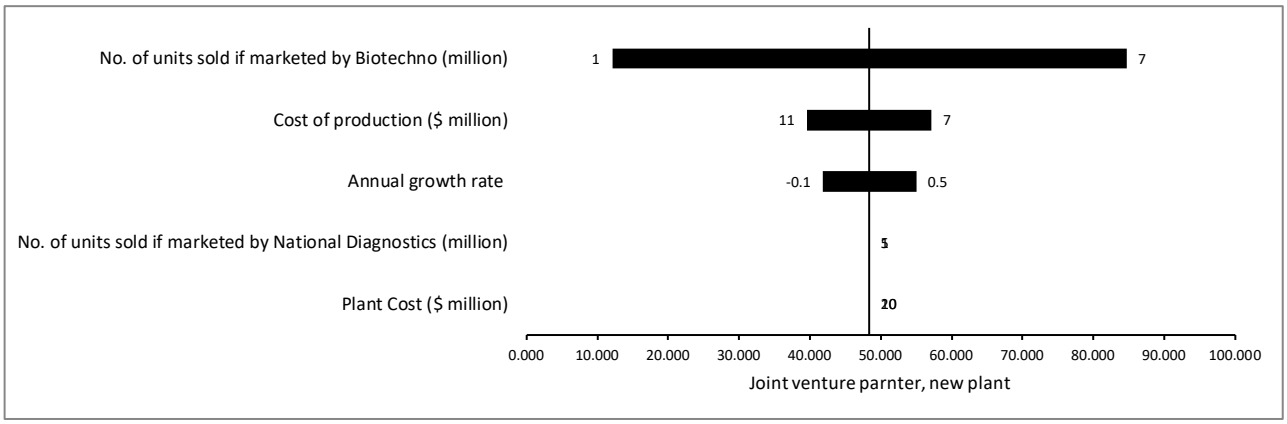
Alternative II: No partner, No new plant

	Input Variables			No partner, No new plant			
Variable	Low	Base	High	Low	Base	High	Swing
n_B	1	3	5	24.200	72.600	88.000	**63.800**
c	11	9	7	59.400	72.600	85.800	26.400
g	-0.1	0.2	0.5	62.700	72.600	77.000	14.300
n_N	1	4	7	72.600	72.600	72.600	0.000
p	10	15	20	72.600	72.600	72.600	0.000



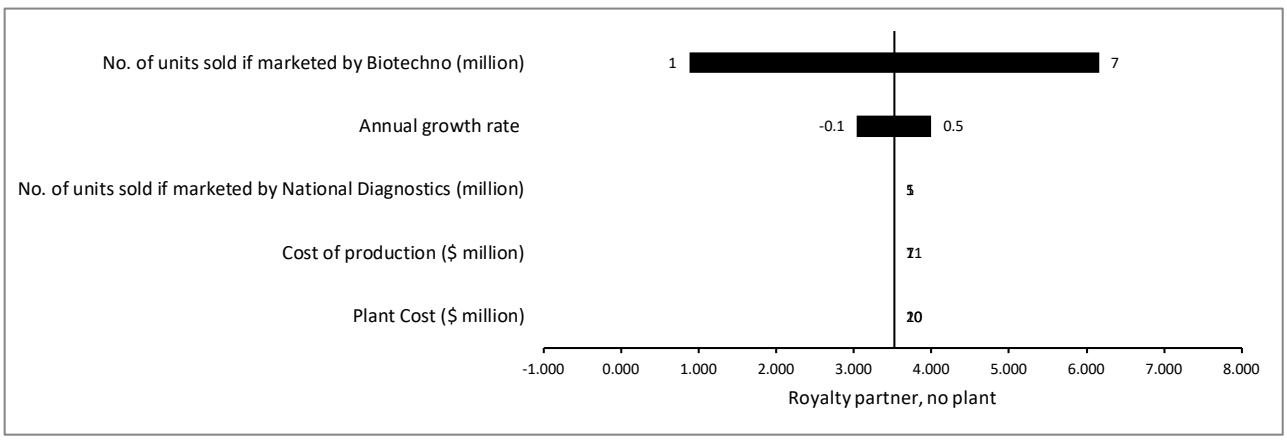
Alternative III: Joint venture partner, Build new plant

	Input Variables			Joint venture partner, New plant			
Variable	Low	Base	High	Low	Base	High	Swing
n_N	1	4	7	12.100	48.400	84.700	72.600
c	11	9	7	39.600	48.400	57.200	17.600
g	-0.1	0.2	0.5	41.800	48.400	55.000	13.200
n_B	1	3	5	48.400	48.400	48.400	0.000
p	10	15	20	48.400	48.400	48.400	0.000

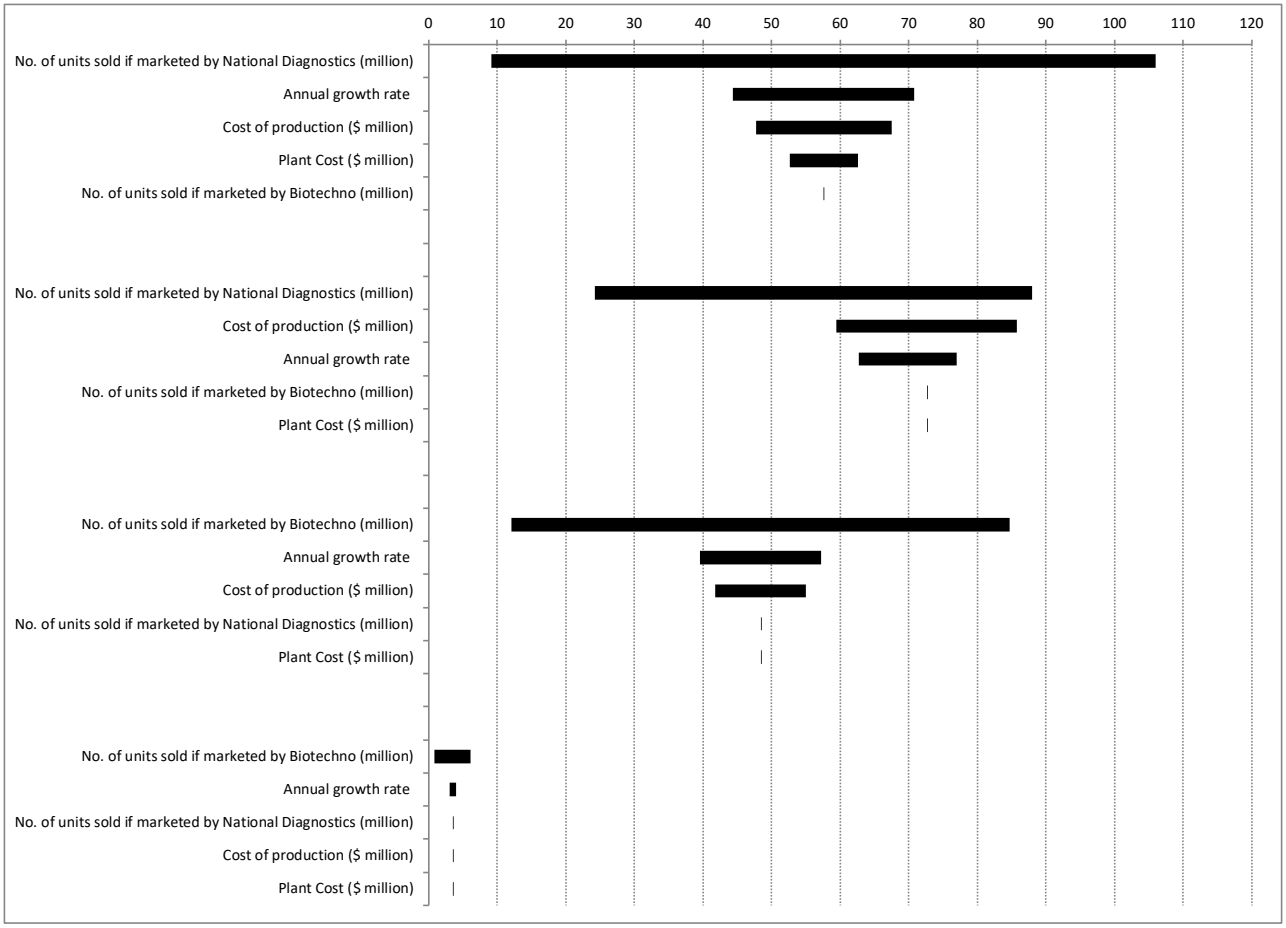


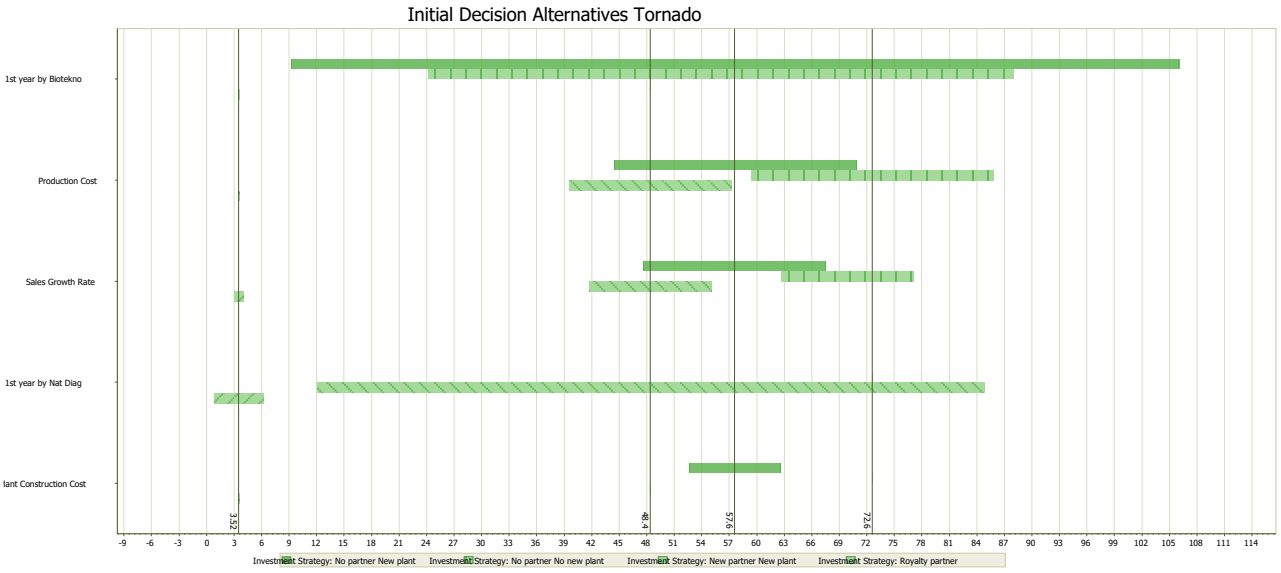
Alternative IV: Royalty partner, No new plant

	Input Variables			Joint venture partner, New plant			
Variable	Low	Base	High	Low	Base	High	Swing
n_N	1	4	7	0.880	3.520	6.160	5.280
g	-0.1	0.2	0.5	3.040	3.520	4.000	0.960
n_B	1	3	5	3.520	3.520	3.520	0.000
c	7	9	11	3.520	3.520	3.520	0.000
p	10	15	20	3.520	3.520	3.520	0.000



Combined Tornado Diagrams





Results of Deterministic Sensitivity

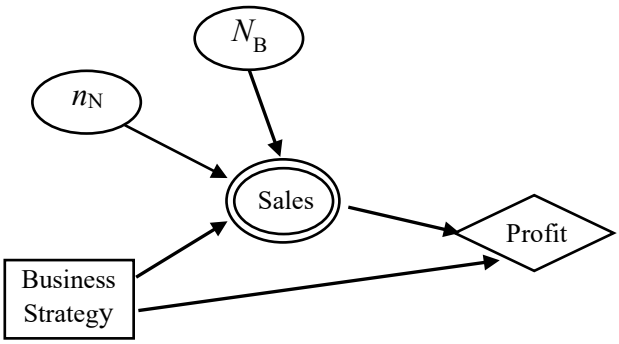
- The sales variables are much more sensitive than the other variables.
- Sensitive variables: n_N and n_B.

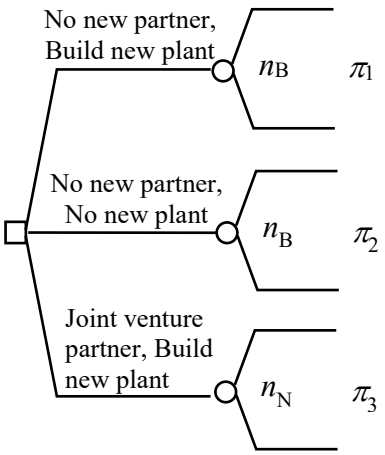
Tornado Dominance

- The best outcomes for alternative IV are always worse than the worst outcomes for alternatives I, II and III.
- Hence alternative IV can be dropped from further consideration.

Probabilistic Evaluation

The Reduced Decision Model





The Reduced Value Model

$$\pi_1 = (20-9)n_B(2+0.2)-15$$
$$= 24.2n_B - 15$$

$$\pi_2 = (20-9)(\min(n_B,3)+\min(1.2n_B,3))$$
$$= 11(\min(n_B,4)+\min(1.2n_B,4))$$

$$\pi_3 = 0.5(20-9)n_N(2+0.2)$$
$$= 12.1n_N$$

Assessing Probability Distributions for n_B and n_N

Using the 5, 50, and 95 percentiles:

- n_B may be represented by a Normal distribution with
  Mean = 3
  Standard deviation = 1.216

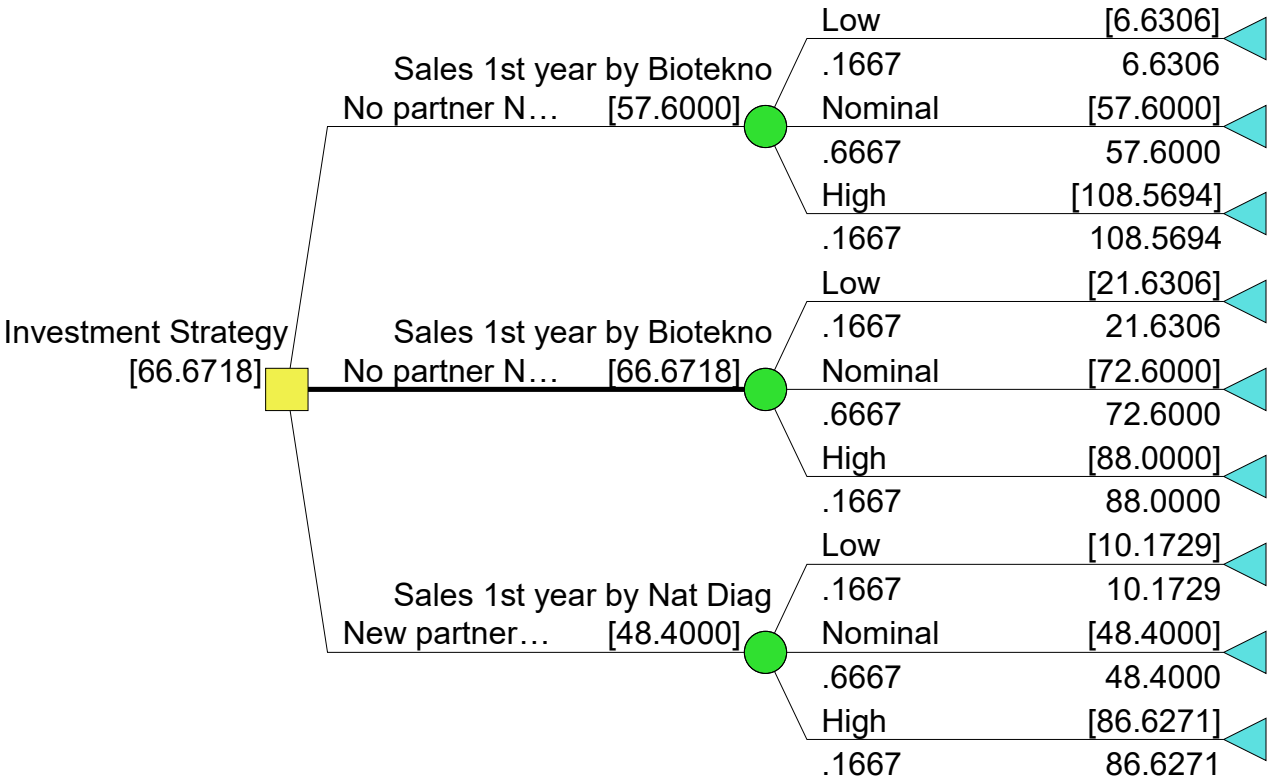
- n_N may be represented by a Normal distribution with
  Mean = 4
  Standard deviation = 1.824

Using the moments matching method, the 3-branch discrete approximations for the two variables are:

n_B	
Value	Probability
0.8938	1/6
3.0000	2/3
5.1062	1/6

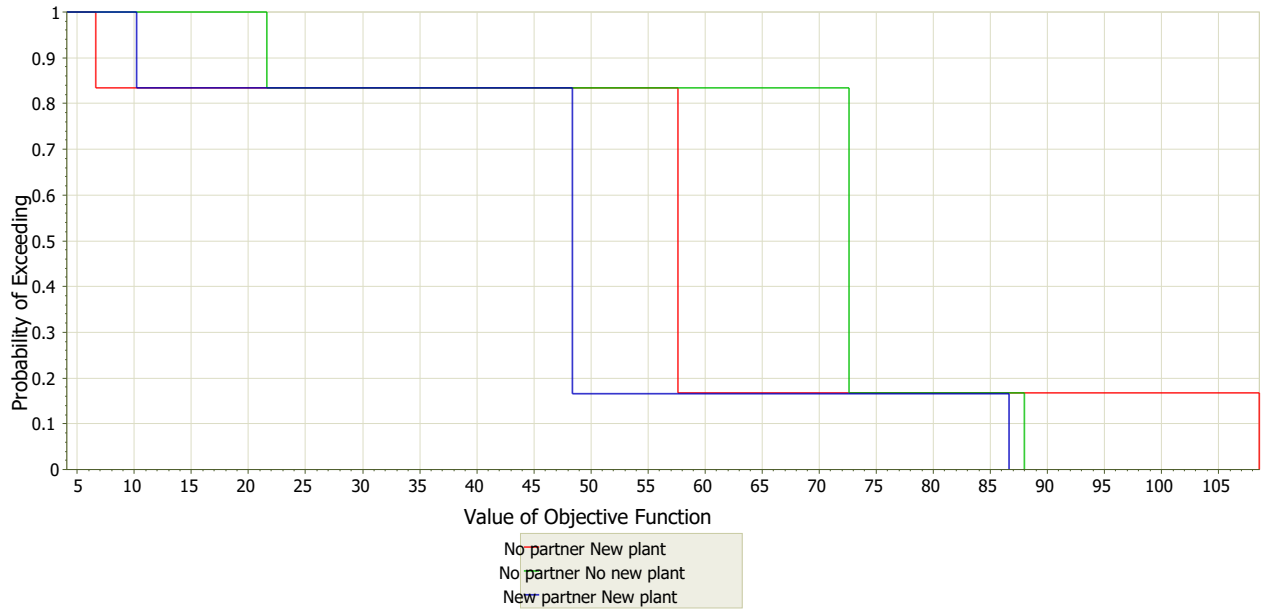
n_N	
Value	Probability
0.8407	1/6
4.0000	2/3
7.1593	1/6

The Decision Tree and Optimal Decision Policy



The best decision is Alternative II: No Partner, No new plant.

Risk Profiles and Stochastic Dominance Analysis



Observation:

- Alt II first-order stochastically dominates Alt III
- Alt II second-order stochastically dominates Alt I

Alternative III will never be chosen under all attitudes (risk-averse and risk-seeking)
Alternative I will never be chosen under all risk-averse conditions.

Recommendation:

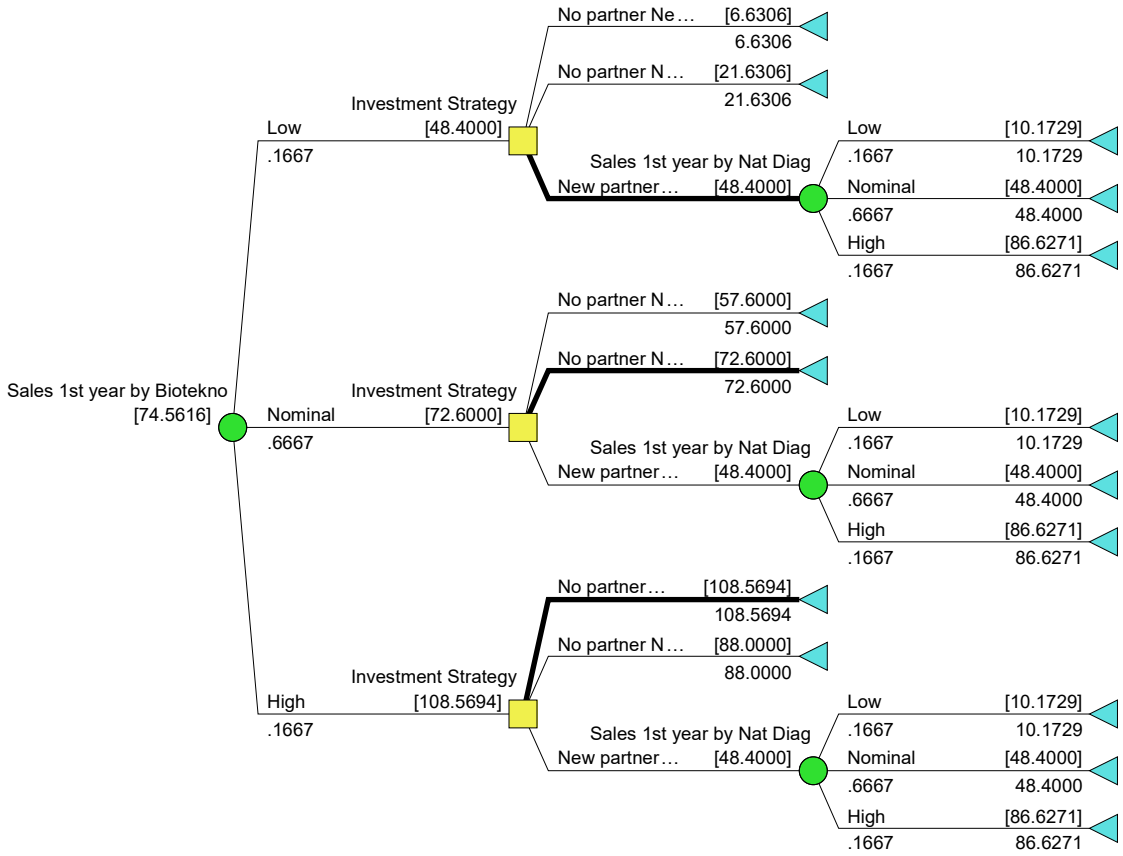
Choose Alternative II - Do not go with a partner, do not build a plant.

Expected Profit under 2-year study period = $66.6718 million

Value of Information Analysis

EVPI for n_B

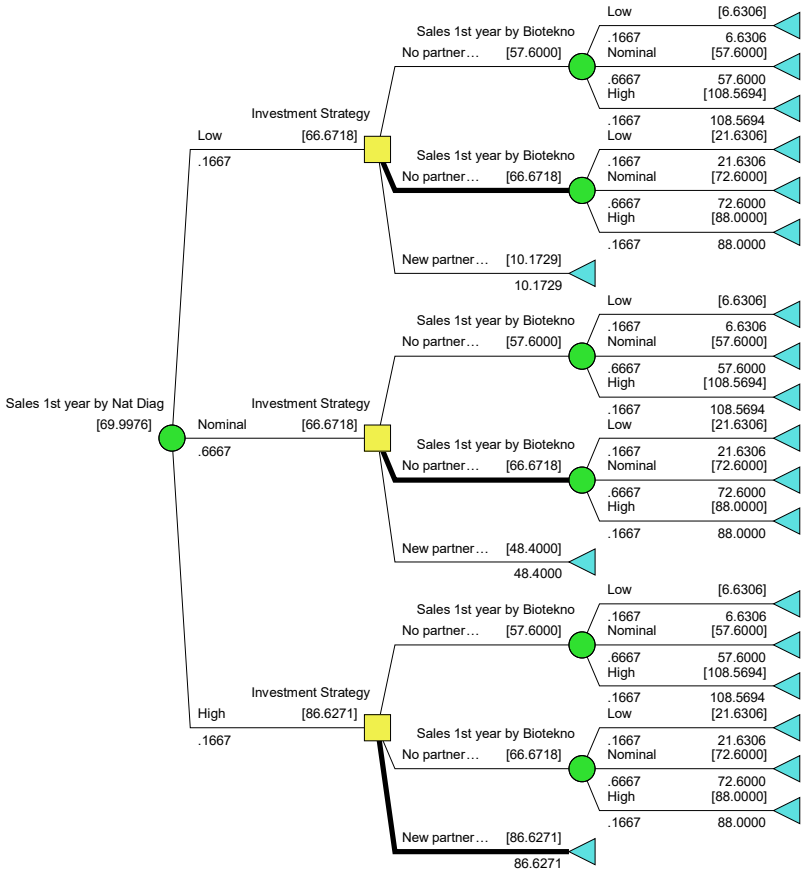
Decision model with free perfect information on n_B



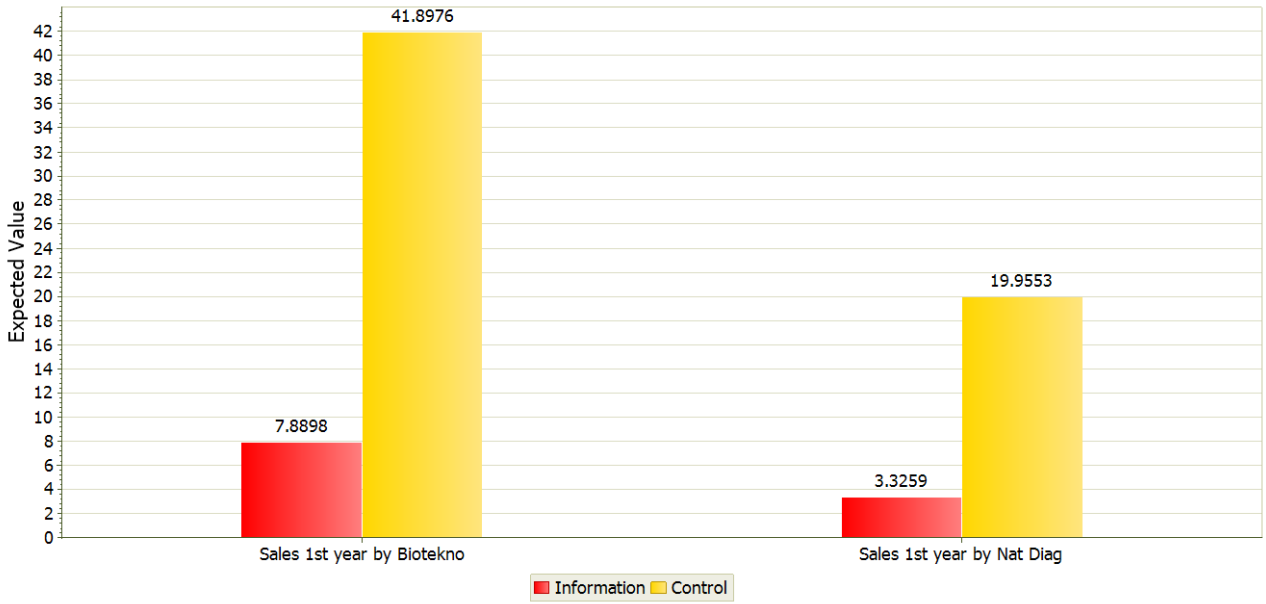
Expected Value of Perfect Information for n_B = 74.5616 – 66.6718 = \$7.8898 million.

EVPI for n_N

Decision model with free perfect information on n_N

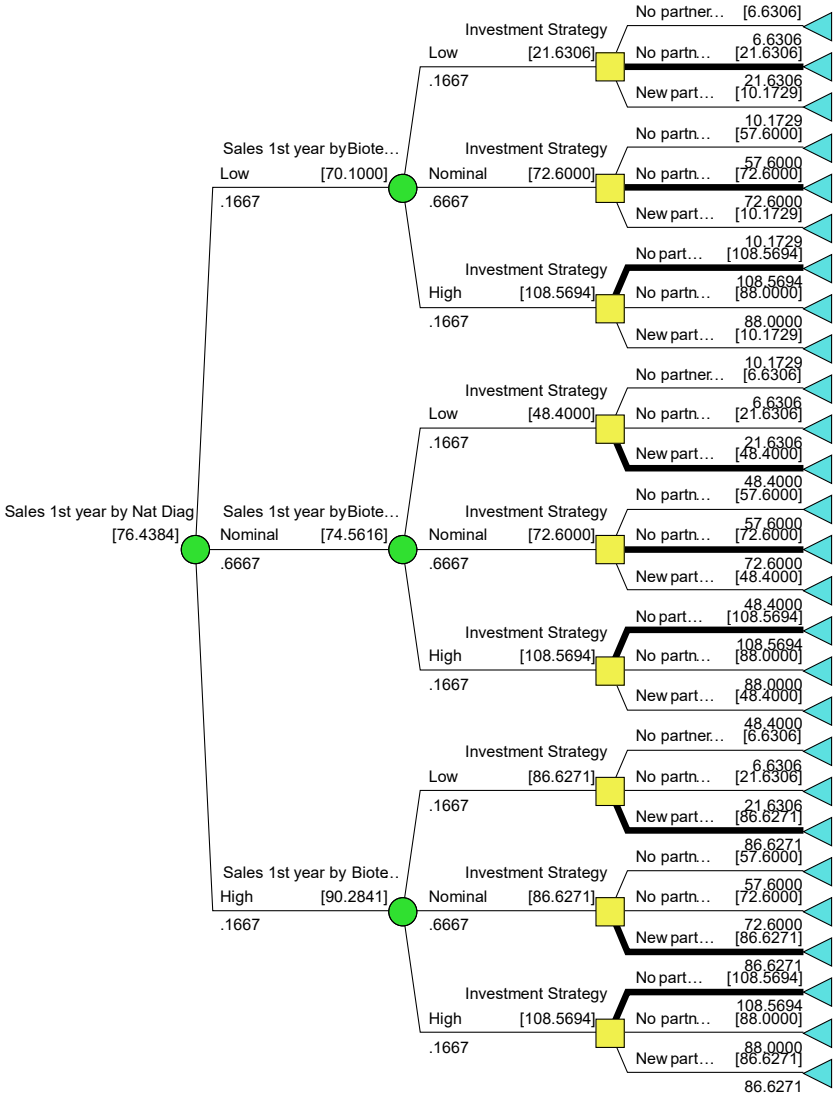


Expected Value of Perfect Information for n_N = 69.9976 – 66.6718 = \$3.3258 million.



Joint EVPI for n_N and n_B

Decision model with free joint perfect information on n_N and n_B



Expected Value of Joint Perfect Information for n_N and n_B = 76.4384 – 66.6718 = $9.7666 million.

Areas of Further Consideration

- Why were the pricing issues fixed and not a decision variable?
- Are there other ways to expand existing production capacity?
- Would the partnership offer be more attractive if Biotekno explicitly considered the cost of marketing the product?
- The sales distribution seems rather tight. There may be an anchoring bias.
- It doesn't seem reasonable that a small company would be risk-neutral in this range of values.
- The no-partnership/build plant alternative might be more attractive if the possible uses of the plant beyond two years were considered.
- The two-year time frame seems unrealistic, despite fast product cycles.