Simple Dynamic Pricing

Creating a Dynamic Pricing Strategy that Maximizes Shareholder Value using the Provisdom Decision Platform

Dynamic Pricing

- Prices can be changed regularly or at any time
- Use information regarding how price changes may affect sales
- Many pricing models are possible
  - Relationship (elasticity) is often unknown and changing, but some learning is possible
  - Other marketing mix factors (product, place, promotion) may be present

Provisdom Approach

- Fast feedback
  - First cut usually takes less than an hour of the decision maker or analyst's time and is completed by Provisdom in less than a day
  - Efforts focus on aligning model with corporation's information
- Use all relevant information
  - Whether data or human knowledge, qualitative or quantitative, even imperfect or incomplete
- Transparent models and results
  - Problem is discretized into as many as billions of possibilities
  - Model can be queried like a database, simulated, or viewed in a decision tree
- Maximize shareholder value
  - Create the strategy that maximizes shareholder value
  - Compare shareholder value of optimal strategy against previous strategy to find value added

Example: Pizza Chain

- Corporate pizza chain has option to change pizza prices whenever advantageous. They can also choose to sell the chain for $20M at any time.
- To advertise any lowering of prices, $10M must be spent.
- Prices may be raised without advertising costs.
- Desire pricing strategy that maximizes shareholder value.

Pricing Model

$$S = \$10\text{M} * (D - P)$$

- S = Yearly Sales Rate
- P = Price per Pizza
- D = Product Desirability
- "Product Desirability" must be inferred from sales and the price. It represents many factors including competitors' prices and market conditions.
- Pricing model is valid for pizza prices between $10 and $15 and for at least ten years, but can be updated at any time.

Product Desirability

- Currently 18
- Uncertainty resembles geometric Brownian motion with constant growth and volatility
- High uncertainty (30% volatility)
- Trending downward (negative 20% expected growth rate)
- Strongly positive relationship with the Market (60% correlation)
- If desirability is less than the price, then sales are zero

Costs and Taxes

- Variable cost per pizza
  - Currently $9
  - Uncertainty resembles geometric Brownian motion with constant growth and volatility
  - Moderate uncertainty (15% volatility)
  - Slight downward trend (negative 5% expected growth rate)
  - Positive relationship with the Market (20% correlation)
  - Positive relationship with product desirability (10% correlation)
- Fixed yearly operating costs total $50M
- Corporate taxes are 39% and apply to all costs and revenue

Building the Strategic Model

- Strategy is modeled in detail for ten years in one-year time steps.
- Pricing choices are in 50-cent intervals between $10 and $15 and are determined yearly.
- Variable Cost per Pizza and Product Desirability are split into two new possible values each year.
- If the chain is still operating at the end of year 10, the future value is estimated by a complex function of the current state at that time.

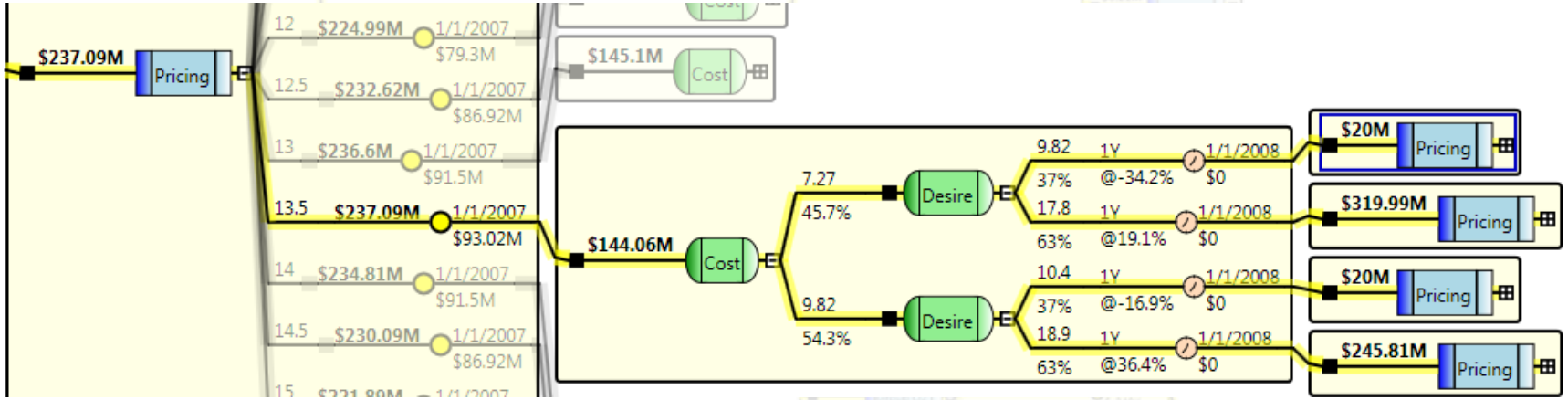
Future Value Beyond 10 Years

$$V = F - \$203.05\text{M} + \$10\text{M} * \min(D - C, 0)^2$$

- *V* = Shareholder Value at Year 10
- *F* = Free Cash Flow (except allowing for negative sales and negative profit margins in the calculation)
- *D* = Product Desirability
- *C* = Variable Cost per Pizza

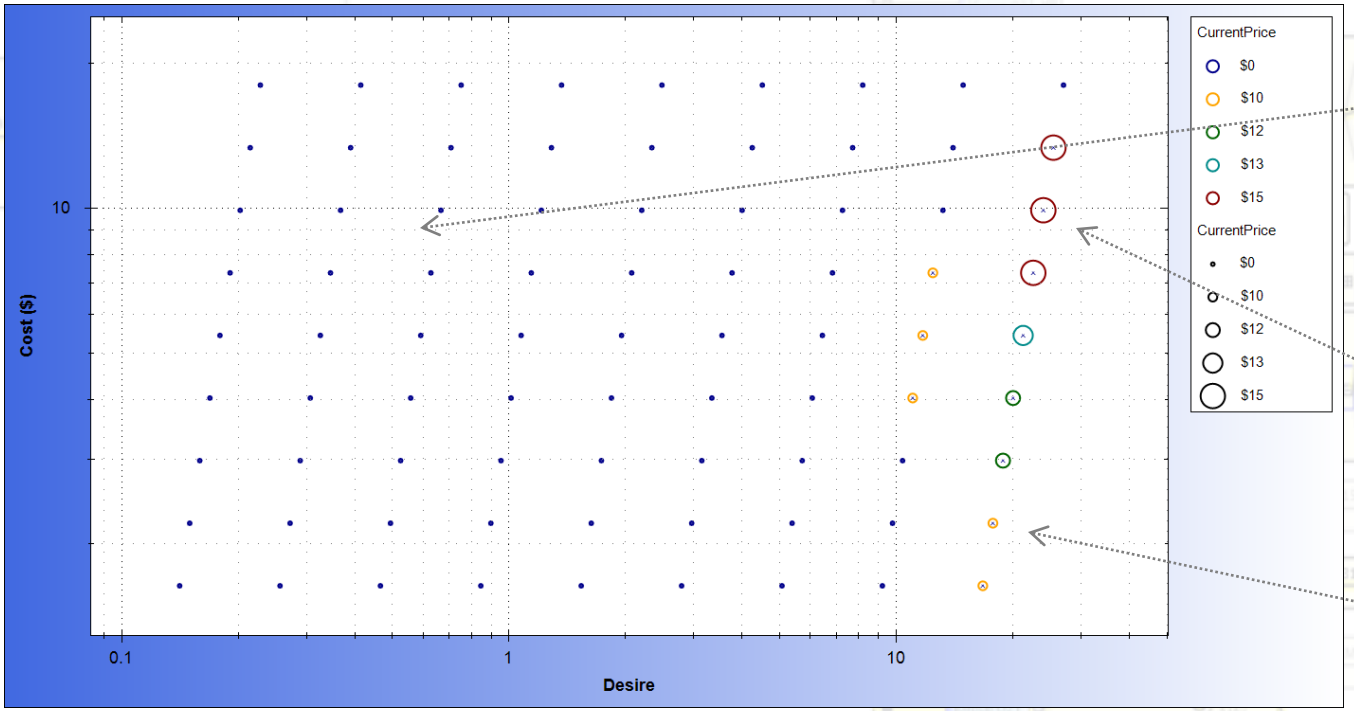
Model Feedback Sample: Screen Shot – Start of Decision Tree

- Useful for investigating model in detail.
- Highlights optimal-choice paths.
- In the tree below, the left-most blue rectangle represents the first pricing choice.
- Today's optimal choice is to set the price per pizza to $13.50, resulting in an NPV of $237.09M.



Model Feedback Sample: Optimal Strategy Variable Cost per Pizza vs. Product Desirability

- Useful for investigating full strategy.
- Graph below shows only year 8 when the previous price was $12.



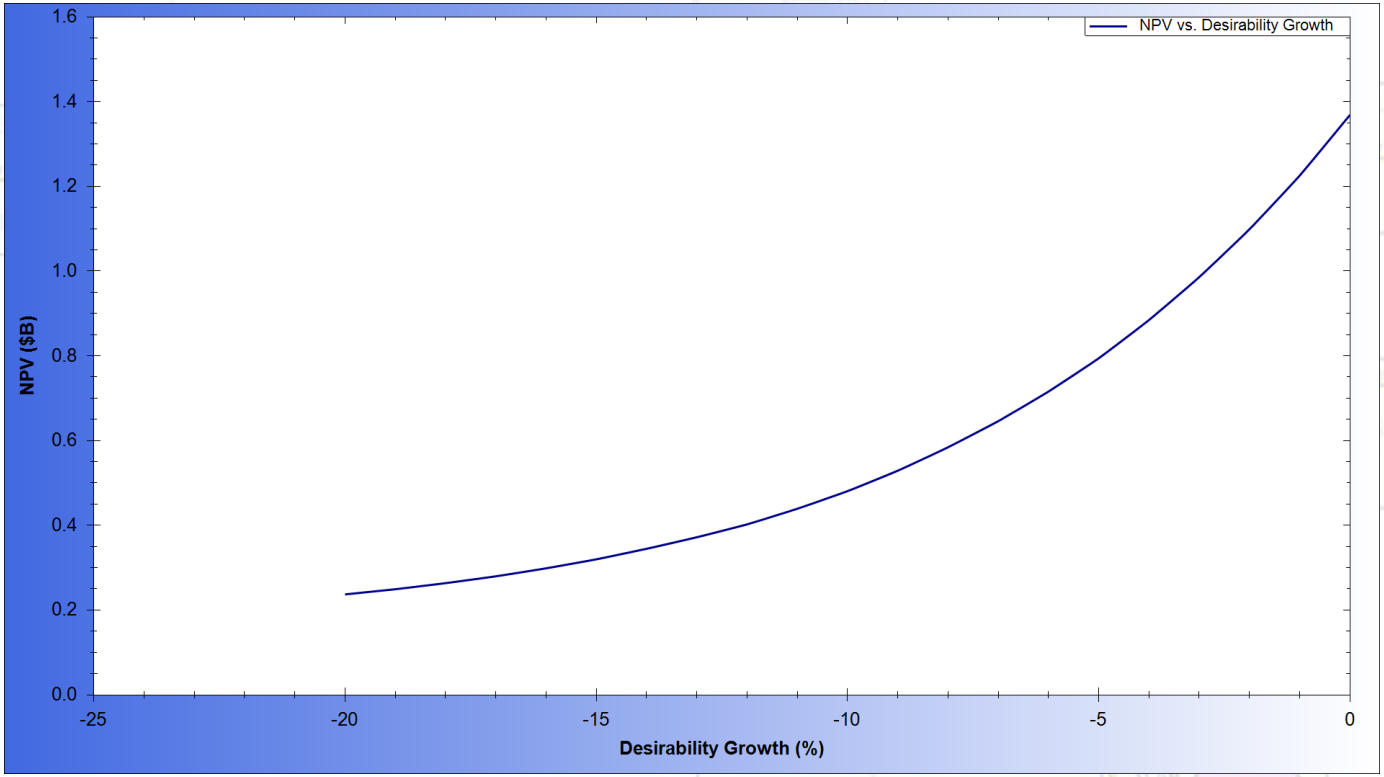
Sell chain when Desirability is not high

Price high when Desirability and costs are high

Price low when Desirability is high and costs are low

Model Feedback Sample: Queries
NPV of Optimal Strategy vs. Desirability Growth

- Useful for providing insight into how model property changes affect value
- For example, increasing desirability growth from -20% to -10% would add approximately $200M in shareholder value.



Model Feedback Sample: Gradient Analysis

- A sensitivity analysis that calculates a change in shareholder value with a change in a model property value.
- Generally calculated with the optimal strategy and all the model properties at their original values.
- Similar to a Tornado diagram but arguably more relevant.
- The table below contains the nine model properties that were given in terms of percentages.

Model Property	d(NPV) / d(%)
Desirability Growth	$11.6M
Desirability Volatility	$8.4M
Cost Growth	(-$4.5M)
Corporate Tax Rate	(-$3.6M)
Risk-Free Rate	(-$3.1M)
Desire-Market Correlation	(-$1.5M)
Cost-Desire Correlation	(-$0.6M)
Cost-Market Correlation	$0.3M
Cost Volatility	(-$0.3M)

- Note that Desirability Volatility has a large, positive impact on the NPV.
- Also note that Cost Volatility has a small, negative impact on the NPV.
- Volatility of an uncertainty generally affects NPV in several ways:
  - With a constant expected growth rate, more volatility means greater expected values.
  - Flexibility becomes more valuable (i.e., the option to change prices or sell the chain).
  - A relationship with the Market is magnified, resulting in changes to the discount rates.

Strategy that Maximizes Shareholder Value

- Today's optimal choice is to set price to $13.50 per pizza.
- To continue to get most accurate optimal strategy over time, automatically or manually feed new state variable values into software.
- Full ten-year strategy is dynamic and complex, roughly:
  - Sell chain when Desirability is not high.
  - Price high when Desirability and costs are high.
  - Price low when Desirability is high and costs are low.
  - No small price drops, e.g. from $12 to $11.50 (due to the advertising costs).

Strategy Comparisons

- Useful for calculating shareholder value added by analysis.
- Table below compares optimal strategy to a strategy of setting a constant price of $12.50 per pizza and to a strategy of setting a constant price of $13.50 per pizza.
- The comparisons are in terms of shareholder value, in both absolute and percentage terms.

Strategy	NPV	$ increase to optimal	% increase to optimal
Optimal Strategy	$237M	$0	0%
Constant Price of $12.50	$27M	$210M	777.8%
Constant Price of $13.50	$38M	$199M	523.7%

Example Modifications and Extensions

- Extend model by adding decisions on when and how much to advertise, along with uncertainties reflecting any effect advertising may have on Product Desirability.
- Replace pricing model with nearly any other price/sales relationship.

Summary of Provisdom Process

1. Gather Initial Information
2. Map Business Problem to Software (using Information Rules)
3. Run Initial Model
   - Find and execute next rule.
   - Find probabilities with a nonlinear optimization solver.
   - Discretize continuously-valued uncertainties and time.
   - Calculate proper discount rates.
4. Analyze Results
5. Refine Model
6. Automate or Update Model Periodically

```
constrain OilPrice in Money &&
    Growth = prop(Oil.Growth) &&
    Volatility = prop(Oil.Volatility) &&
    Yield = prop(Oil.Yield);
```