An Introduction to Market Simulations

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Agenda

- Why conduct simulations?
- Simulation methods
- Search methods

Background

A "choice laboratory" for testing of alternative marketing strategies

- Reflect real-world behavior
  - Represent idiosyncratic preferences of segments and individuals

- Results expressed in terms that make sense to managers

	Product 1	Product 2	Product 3
Brand	Visa	MasterCard	Discover
Interest Rate	15% interest	20% interest	15% interest
Credit Limit	$2,500 credit limit	$5,000 credit limit	$7,500 credit limit
Share	**54%**	**8%**	**37%**

Examining utilities and importances only gets you so far

- Average utilities cannot tell the whole story
- Fallacy of Division

Preferred Color?

- Consider the following utilities:

	Blue	Red	Yellow
Respondent #1	50	40	10
Respondent #2	0	65	75
Respondent #3	40	30	20
Average	**30**	**45**	**35**

- Red has the highest <u>average</u> preference
- But, does any <u>one</u> respondent prefer red?

Chosen Color?

- Each respondent's preferred color:

	Blue	Red	Yellow	"Choice"
Respondent #1	50	40	10	**Blue**
Respondent #2	0	65	75	**Yellow**
Respondent #3	40	30	20	**Blue**
Average	**30**	**45**	**35**	

- Blue "chosen" twice, Yellow once

Market Simulators help to answer strategic questions

- At what price will people switch to a competitor?
- Can we modify our product to reduce cost while maintaining share?
- Should we launch a high-end product or a budget model (or both)?
- Will the new product cannibalize our own sales?

Competitive Effects

- Assume 80% of market prefers round widgets, and 20% prefers square ones. Which should you take to market?

- In the absence of any other information, round would be the logical choice

- But what if there currently are 10 competitors in the market, ALL only offering round widgets?

Check out our new video

OK, simulations are good—but how do we do it?

- First we need utilities for product features, ideally for each respondent (HB – hierarchical Bayes)

		Resp. 1	Resp. 2	…	Resp. 500
Flavor	Vanilla	2.5	-1.0		3.7
	Chocolate	1.8	1.0		0.5
Price	$0.25	5.3	1.2		1.0
	$0.35	3.2	0.7		0.8
	$0.50	1.4	-1.9		0.5

Simulation Methods

Many Ways to Simulate

- First Choice Rule (also called “maximum utility rule”)
- Logit Probability Rule (also called “share of preference rule”)
- Randomized First Choice

“First Choice” Market Simulations

- For each respondent, assume respondent chooses the product with the highest utility

- Count these respondent choices

Market Simulation Example

		Resp. 1	Resp. 2	…	Resp. 500
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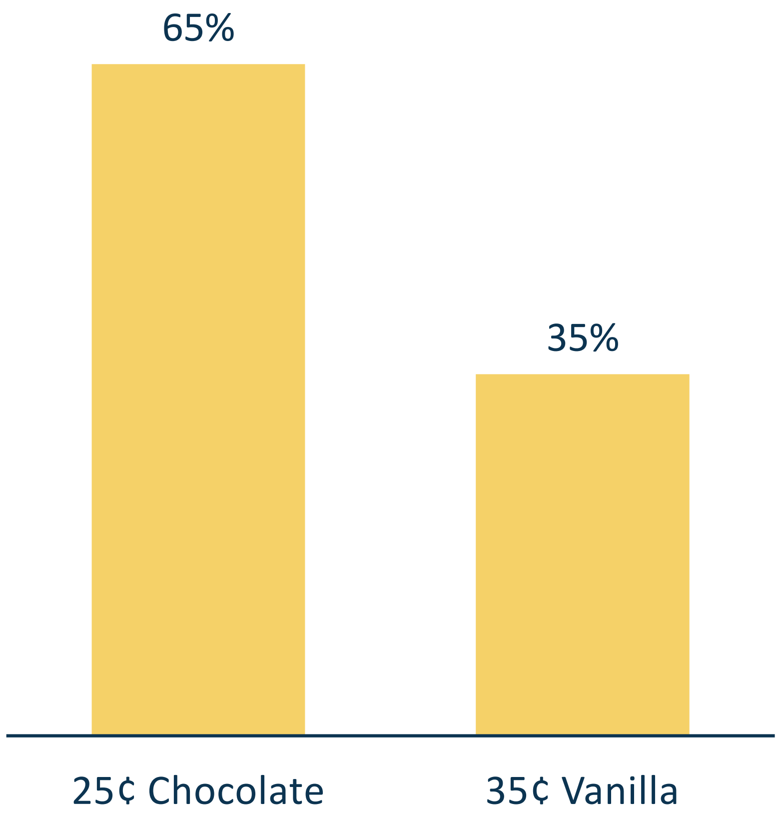
	Chocolate	1.8	1.0		0.5
Price	$0.25	5.3	1.2		1.0
	$0.35	3.2	0.7		0.8
	$0.50	1.4	-1.9		0.5
			Simulation		
	$0.25 Choc.	7.1	2.2		1.5
	$0.35 Van.	5.7	-0.3		4.5
	Winner	**Chocolate**	**Chocolate**		**Vanilla**

Market Simulation Results

- Predict responses for 500 respondents, and we might see “shares of preference” like:
  – Where 65% of respondents prefer the 25¢ Chocolate cone



How Realistic is the First Choice Rule?

- First choice model is simple to do and easy to understand, but usually oversimplifies consumer behavior
  - Assumes a product barely preferred over another is chosen 100% of the time (winner takes all)

- Less efficient use of data: we learn about which product is preferred, but don’t capture anything about relative preferences of not preferred options
  - Standard errors of simulated shares relatively high

When to use it

- Despite the theoretical problems, there are certain conditions under which First Choice can work quite well
  - Large sample size
  - The situation we want to model really is “winner take all” (e.g. large purchases where consumers actually DO only ever “buy” one)
    - Automobiles
    - Refrigerators
    - Etc.

The Unpredictable Buyer

- Buyers never purchase with 100% certainty the product our model says is most preferred within a set
  - Error present in model estimation, respondent choices
  - Some “random” behavior occurs
  - Other unaccounted for influences (e.g. out-of-stock, children in the cereal aisle) can alter choice
  - Variety seeking

How to Model Uncertain Behavior?

- For each respondent, perhaps we can estimate continuous probabilities of purchase rather than either 0% or 100% each alternative (vote splitting)

	First Choice	"Share of Preference"
A	0%	10%
B	100%	60%
C	0%	30%

- But how to do it?

The Logit Rule (Share of Preference)

- Available when utilities estimated using a logit model
- Probability of choosing alternative A with utility U_a from a set of product alternatives {A B C} is

$$P(A) = \frac{\exp(U_a)}{(\exp(U_a) + \exp(U_b) + \exp(U_c))}$$

- Where "exp(U_i)" is the antilog of U_i, also known as raising the constant "e" (2.7183…) to the power U_i

Logit Rule Example

- Assume three product alternatives with the following utilities (after adding up their respective part worths):

A	0.75
B	0.00
C	-1.25

- Compute the share of A:

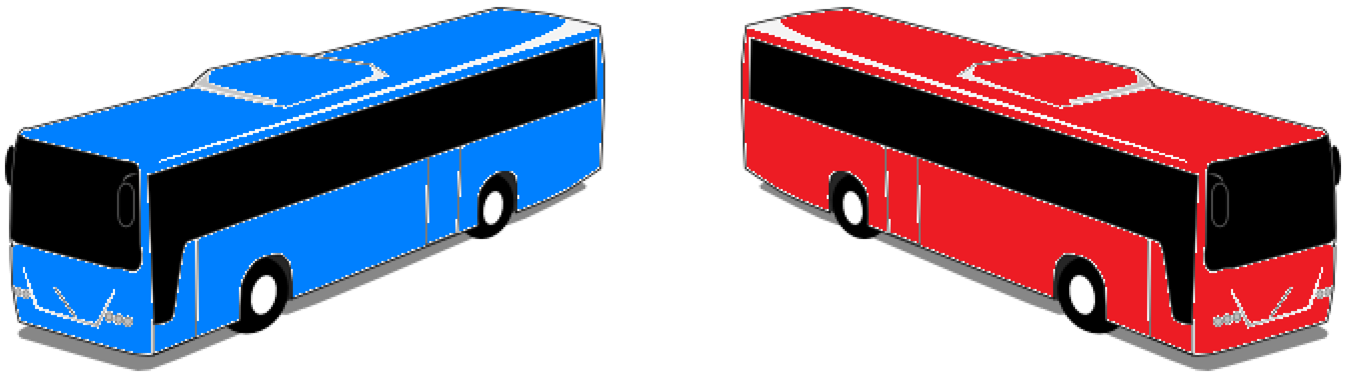
$$P(A) = \frac{\exp(0.75)}{(\exp(0.75) + \exp(0.00) + \exp(-1.25))}$$

$$P(A) = \frac{2.117}{(2.117 + 1.00 + 0.287)}$$

$$P(A) = 62.2\%$$

Red-Bus/Blue-Bus Problem (IIA)

- Logit has a property called "Independence of Irrelevant Alternatives" or IIA
  - This property states that the ratio between any two alternatives' shares should be independent of all other alternatives
  - This property also implies constant substitution rates, which is unrealistic



IIA Example

- Consider two drink alternatives, Pepsi and Milk, with the following logit utilities:

Pepsi	1.0
Milk	2.0

- Compute share of Pepsi

$$P(Pepsi) = \frac{\exp(1)}{(\exp(1) + \exp(2))}$$

$$P(Pepsi) = \frac{2.72}{(2.72 + 7.39)}$$

$$P(Pepsi) = 26.9\%$$

$$P(Milk) = \frac{7.39}{(2.72 + 7.39)} = 73.1\%$$

Consider the Introduction of Coke

- Assume a new alternative appears, Coke, with a logit utility (like Pepsi) of 1.0
- What are the new shares for Pepsi, Milk, and Coke?
    - Pepsi = 2.72/(2.72+7.39+2.72) = 21.2%
    - Milk = 7.39/(2.72+7.39+2.72) = 57.6%
    - Coke = 2.72/(2.72+7.39+2.72) = 21.2%
- Coke takes share proportionally from Pepsi and Milk:

	Original	New	Proportional Change
Pepsi	26.89	21.19	-21.19%
Milk	73.11	57.61	-21.19%
Coke	N/A	21.19	

Reducing IIA Troubles

- When we use Latent Class or HB modeling to generate utilities and to accommodate heterogeneity, the Red Bus/Blue Bus problem may be reduced.
  - Similar products tend to compete more closely with one another.

- Simulation methods that directly assess and penalize product similarity can help even more.

Randomized First Choice (RFC)

- RFC sits in a middle ground between the First Choice and Logit choice rules
- Can be used with aggregate or disaggregate utilities
- “Splits” shares but reflects more accurate substitution effects for similar products than does the Logit Rule
- Is tunable, in terms of scale and product similarity

Market Simulation – One Vote/Respondent

		Resp. 1	Resp. 2	…	Resp. 500
Flavor	Vanilla	2.5	-1.0		3.7
	Chocolate	1.8	1.0		0.5
Price	$0.25	5.3	1.2		1.0
	$0.35	3.2	0.7		0.8
	$0.50	1.4	-1.9		0.5
			Simulation		
	$0.25 Choc.	7.1	2.2		1.5
	$0.35 Van.	5.7	-0.3		4.5
	Winner	**Chocolate**	**Chocolate**		**Vanilla**

Splitting Respondents' Votes

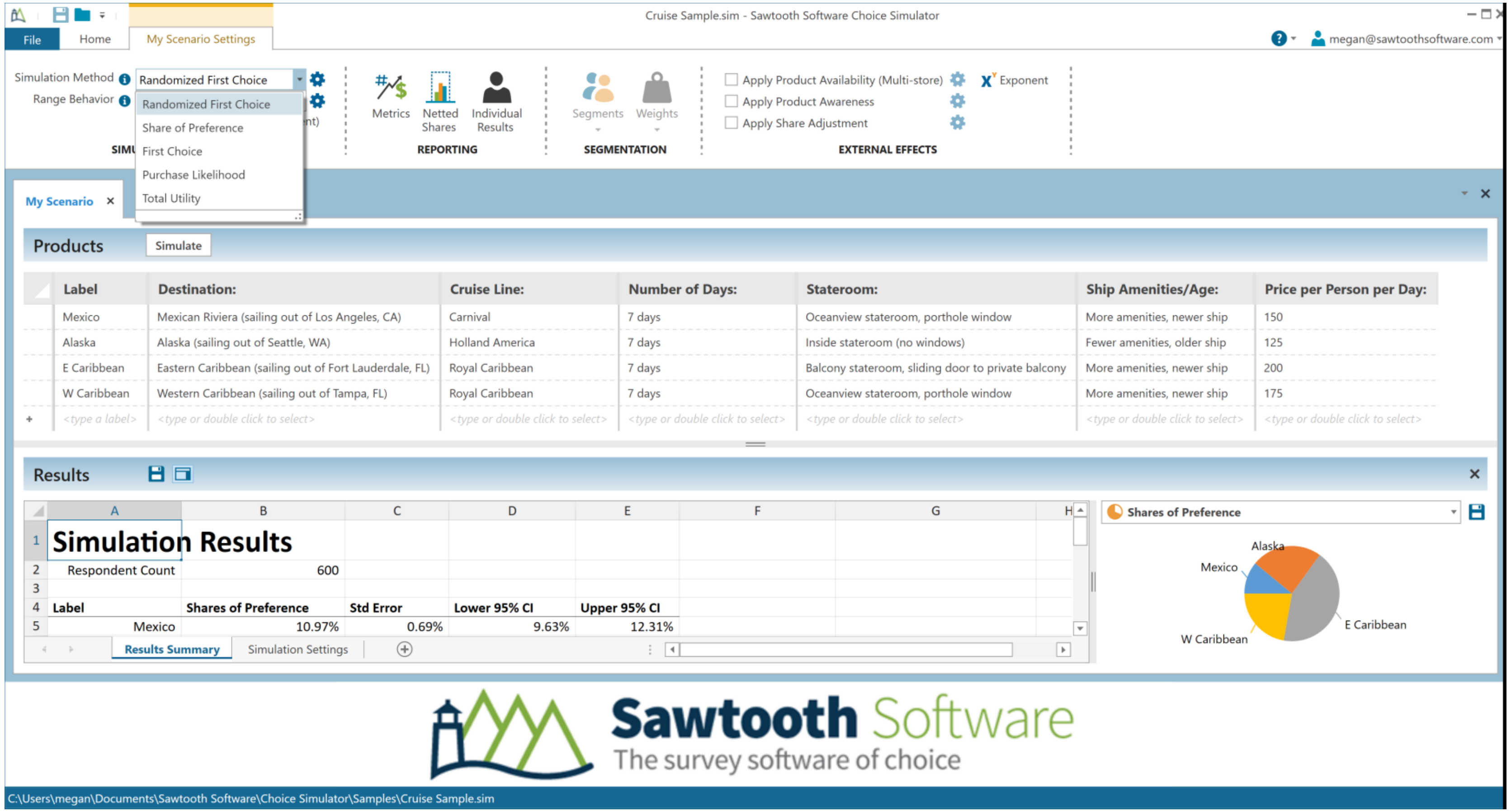
		Resp. 1 Actual Utilities	Resp. 1 Iteration 1	…	Resp. 1 Iteration 10,000
Flavor	Vanilla	2.5	2.5 + 0.015		2.5 + 1.5
	Chocolate	1.8	1.8 - 0.75		1.8 – 1.25
Price	$0.25	5.3	5.3+0.20		5.3-0.75
	$0.35	3.2	3.2-1.33		3.2+0.5
	$0.50	1.4	1.4+2.15		1.4-0.14
			Simulation		
	$0.25 Choc.	7.1	6.55		5.1
	$0.35 Van.	5.7	4.385		7.7
	Winner	**Chocolate**	**Chocolate**		**Vanilla**

Weaknesses of RFC

- If a correction for similarity is applied to Price
  - Creates distortions in the demand curve due to severe product similarities of reference brands held all at the same price
  - But, you can turn off the “correction for product similarity” for price!

- If simulating for many (say, 20+ products) some shares can become so small that the random component introduced by RFC makes such small shares imprecise, unless you increase sampling iterations considerably.

Demo



Cruise Sample.sim - Sawtooth Software Choice Simulator
File
Home
My Scenario Settings
megan@sawtoothsoftware.com
Simulation Method
Range Behavior
Randomized First Choice
Randomized First Choice
Share of Preference
First Choice
Purchase Likelihood
Total Utility
Metrics
Netted Shares
Individual Results
REPORTING
Segments
Weights
SEGMENTATION
Apply Product Availability (Multi-store)
Apply Product Awareness
Apply Share Adjustment
Exponent
EXTERNAL EFFECTS
My Scenario
Products
Simulate
Label
Destination:
Cruise Line:
Number of Days:
Stateroom:
Ship Amenities/Age:
Price per Person per Day:
Mexico
Mexican Riviera (sailing out of Los Angeles, CA)
Carnival
7 days
Oceanview stateroom, porthole window
More amenities, newer ship
150
Alaska
Alaska (sailing out of Seattle, WA)
Holland America
7 days
Inside stateroom (no windows)
Fewer amenities, older ship
125
E Caribbean
Eastern Caribbean (sailing out of Fort Lauderdale, FL)
Royal Caribbean
7 days
Balcony stateroom, sliding door to private balcony
More amenities, newer ship
200
W Caribbean
Western Caribbean (sailing out of Tampa, FL)
Royal Caribbean
7 days
Oceanview stateroom, porthole window
More amenities, newer ship
175
Results
Simulation Results
Respondent Count
600
Label
Shares of Preference
Std Error
Lower 95% CI
Upper 95% CI
Mexico
10.97%
0.69%
9.63%
12.31%
Results Summary
Simulation Settings
Shares of Preference
Alaska
Mexico
E Caribbean
W Caribbean
Sawtooth Software
The survey software of choice
C:\Users\megan\Documents\Sawtooth Software\Choice Simulator\Samples\Cruise Sample.sim

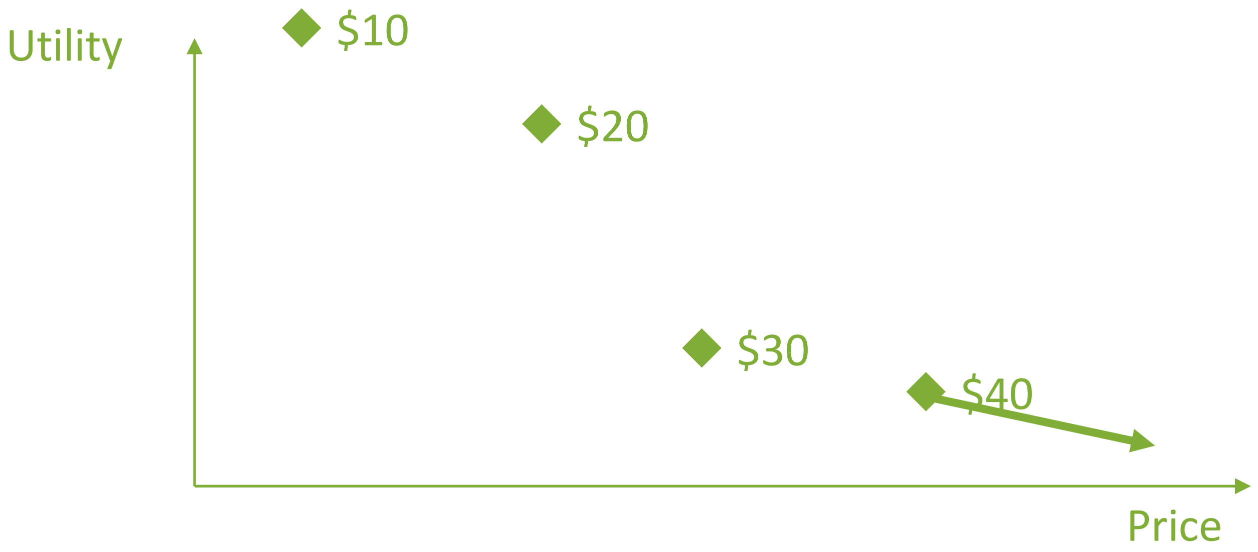
Interpolation

- Straight-line interpolation often used to simulate for a level between two that were measured:

- Usually a fairly accurate, safe procedure for “ordered” attributes

Extrapolation

- Extrapolation is dangerous - used when clients request a simulation beyond the levels included in the design



- Who says that the relationship from $30 to $40 should continue beyond $40?

Search Methods

Why use search methods?

- Most simulators answer the question, “How good would THIS product be?”

- But researchers often spend a lot of time manually trying to discover, “What product would be BEST?”

An all too common approach…

- Look at the average utilities and pick the best levels

- But…
  - Doesn't account for heterogeneity
  - Doesn't account for costs
  - May not be possible
  - End up with unprofitable product – all best features at lowest price, for instance.

Conjoint simulators offer perhaps the best means for product optimization

- Can account for current competitive environment
- Can account for respondent heterogeneity
- Can accurately project market choices

Sawtooth Software's Choice Simulator

- Automatically run thousands of simulations to find optimal product or product set
- Can optimize one or any combination of the following:
  - Preference Share
  - Revenue
  - Profitability
  - Cost
- Set up filters to limit optimization answers (i.e. do not allow products with a negative profit)
- Include existing products in optimization

Example Scenario

"Searched" Product

"Fixed" Competitors

My Scenario ×

Products Simulate

Label	Destination:	Cruise Line:	Number of Days:	Stateroom:	Ship Amenities/Age:	Price per Person per Day:
Mexico	=range(1,6)	Carnival	=range(1,5)	=range(1,3)	=range(1,2)	=range(100,200,25)
Alaska	Alaska (sailing out of Seattle, WA)	Holland America	7 days	Inside stateroom (no windows)	Fewer amenities, older ship	125
E Caribbean	Eastern Caribbean (sailing out of Fort Lauderdale, FL)	Royal Caribbean	7 days	Balcony stateroom, sliding door to private balcony	More amenities, newer ship	200
W Caribbean	Western Caribbean (sailing out of Tampa, FL)	Royal Caribbean	7 days	Oceanview stateroom, porthole window	More amenities, newer ship	175
+ <type a label	<type or double click to select>	<type or double c	<type or double click t	<type or double click to select>	<type or double click to sele	<type or double click to select>

Enormous Search Space

- Suppose we have 10 attributes, each with 5 levels.
- There are then 5^{10} possible product configurations, or almost 10 million! (Okay, only 9,765,625)
- If optimizing multiple products simultaneously, the problem gets even bigger. (9,765,625 *9,765,624*…)
- For some larger conjoint optimization problems, to search through all possible combinations might take the fastest computers today months or even years to search the entire space.

Three available algorithms for product searches

Exhaustive

Simple; Examines all possible combinations; Guaranteed to find the global optimal solution; Can conduct Multi-Objective Searches

Total search space can be enormous (10 attributes w/ 5 levels each makes for 5^10, or 10 million combinations!)

Grid

Extremely fast if search space is large; Accurate if search space is single-peaked; Used to reduce Exhaustive search domain

Not guaranteed to find the global optimal solution if several peaks

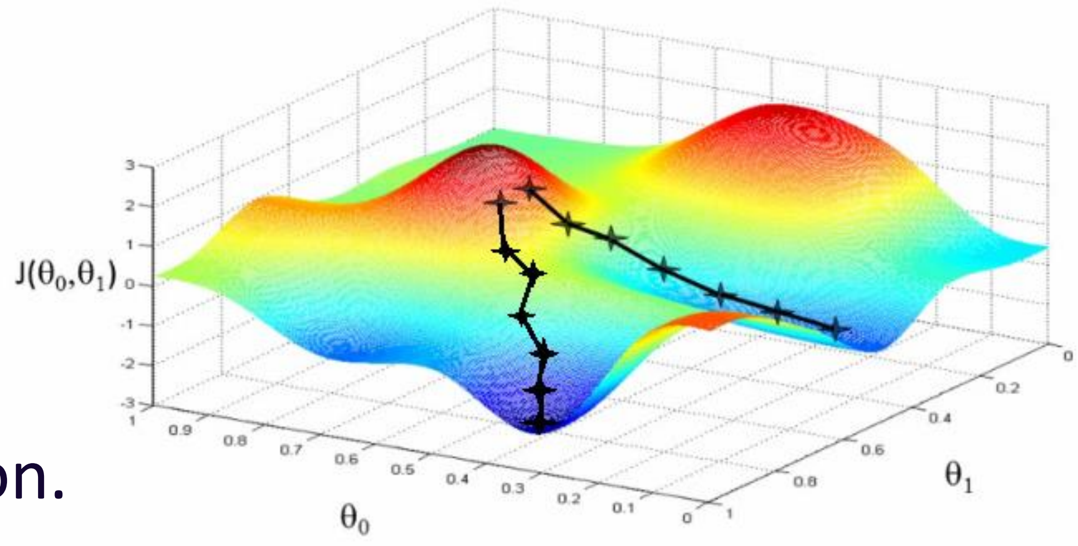
Genetic

Faster than Exhaustive if search space is large (but longer than Grid); Finds a variety of near-optimal solutions, and most times the single best optimal solution; Can conduct Multi-Objective Searches

Still not guaranteed to find the global optimal solution, but Genetic is less vulnerable than Grid search to finding the local optimum

Grid Algorithm

- It isn't necessary to try all possible combinations to find nearly-optimal products.
- Grid changes one attribute at a time (holding all others constant) and keeps any change that improves the solution. This repeats until no other change results in a better solution.



- If the response surface is single-peaked, it is guaranteed to find the global optimum.

Genetic Algorithm

- Based on concepts of evolutionary biology and Darwinian theory (survival of the fittest)

- Each searched product field is a “chromosome”, and the options (attribute levels) for those fields are the “genes”

- Each solution (a set of chromosomes) is an “organism”

Basics Steps for GA (1)

- Generate pool of organisms (products) using random or targeted values
- Evaluate the organisms in terms of their “fitness” (utility, share, etc.)
- Choose parents based on their fitness and produce “offspring”
  - Offspring are a combination of the parents’ traits
- Evaluate the offspring’s fitness
- “Cull” the population by removing the least fit members of the population
  - The number remaining is the original pool size

Basics Steps to GA (2)

- Offspring are formed through random cross-over and mutation:

	A1	A2	A3	A4	A5
Parent “A”	4	2	1	3	5
Parent “B”	3	1	1	2	5
Offspring “C”	3	2	1	3	3

Mutation

Cross-Over

Basic Steps to GA (3)

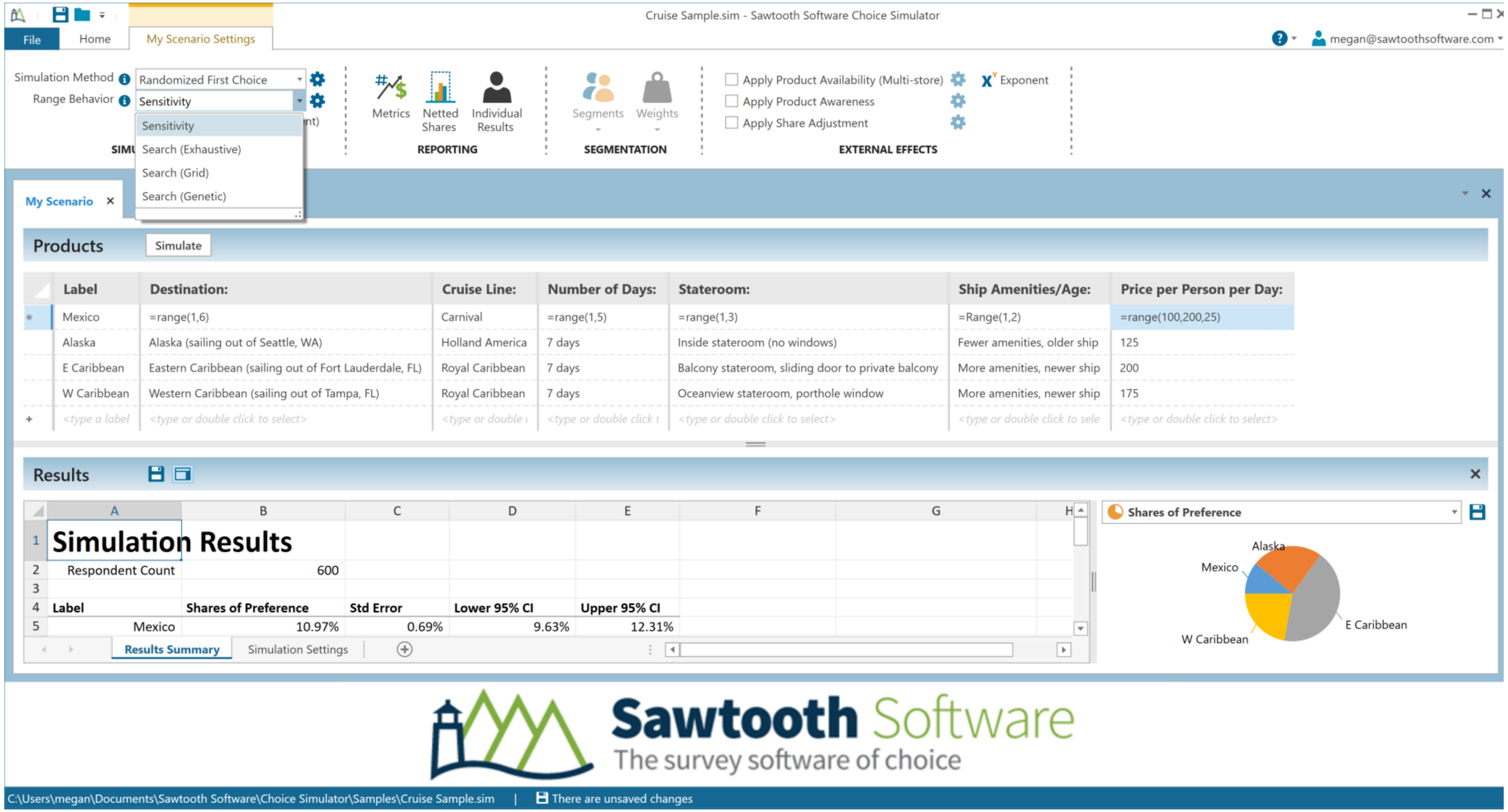
- Each iteration of evaluation, creating and culling the population is called a “generation”

- Generations continue until the maximum is reached OR the population fails to improve

Targeted Initial Populations

- Thanks to Scott Ferguson for doing research in this area
- Genetic algorithms generally start with random solutions, but could it run faster if it started from non-random?
- Uses Grid searches on individual respondents to create solutions that appeal to groups found via k-means
- Generally reduces the number of generations needed to converge, and can improve final solution quality

Demo



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Search (Grid)
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Apply Product Availability (Multi-store)
Apply Product Awareness
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EXTERNAL EFFECTS
My Scenario
Products
Simulate
Label
Destination:
Cruise Line:
Number of Days:
Stateroom:
Ship Amenities/Age:
Price per Person per Day:
Mexico
=range(1,6)
Carnival
=range(1,5)
=range(1,3)
=Range(1,2)
=range(100,200,25)
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The survey software of choice
C:\Users\megan\Documents\Sawtooth Software\Choice Simulator\Samples\Cruise Sample.sim
There are unsaved changes

Recommendations

- Run Exhaustive IF number of attribute level combinations to search is feasible (ex. 5 attributes w/ 4 levels each is 4^5, only 1024 scenarios)
- If Exhaustive is not feasible, start with Grid search. Run multiple passes and if the same answer is always obtained, it is likely the optimum. If not, reduce the domain and re-run Exhaustive.
- Use Genetic if the response surface is irregular with many peaks.
- Use Exhaustive or Genetic if the business goal is to consider multiple objectives, such as maximizing profit and share.

Access to the choice simulator

- Currently a suite holder? The Advanced Simulation Model (ASM) Choice Simulator is included.
- Have a CBC or Advanced CBC subscription? Enjoy free access to the simulator too.
  - But you'll need the ASM module to conduct optimization searches!
- Not currently a user? Subscribe now!

Questions?

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And don’t forget…

Shares of Preference Don't Always Match Actual Market Shares

- Conjoint simulator assumptions usually don't hold true in the real world, but this doesn't mean that conjoint simulators are not valuable!
  - Simulators turn esoteric "utilities" into concrete "shares"
  - Conjoint simulators predict respondents' interest in products/services assuming a level playing field
  - Provides insights into what respondents value, even if they cannot always act on those values in the real marketplace.

A conjoint market simulator assumes…

- We have interviewed the right people
- Each person is in the market to buy
- We’ve used a proper measurement technique
- Respondents have answered reliably and truthfully
- All attributes that affect buyer choices in the real world have been accounted for

More assumptions

- Equal availability (distribution)
- Respondents are aware of all products
- Long-range equilibrium (equal time on market)
- Equal effectiveness of sales force
- No out-of-stock conditions

External Effects

- Product availability
  - Types of availability
  - Importing granular information
  - Simulated trips
    - Special rules for RFC
  - Per respondent probabilities
- Product awareness
  - How to collect the data
  - Cautions – applied at product level, not at brand level
- Share adjustment
  - Utility adjustment
  - Aggregate share adjustment
  - Theory & cautions
- Tuning the Exponent