

Modelling “Irrational” Behavior

Behavioral Economics Meets Actuarial Science

June 15, 2021

Randall A. Stevenson, ASA, MAAA, MSc

For the Actuaries’ Club of the Southwest

RandallS@HauseActuarial.com



Topics

- Historical Context of Research
- A Primer on Behavioral Economics
- The Classical Utility Function
 - Advantages
 - Disadvantages
- Considerations for a Preference Function
 - What is Actuarial Utility and a Preference Function
 - Determining Parameters
 - Combining Stakeholders' Preferences
- Designing a Preference Function
- Brain Candy (Time Permitting)

Historical Context

- I saw unusual things in the pension and life actuarial fields and in the investment fields which did not fit with the traditional utility function.
 - DROP Participation
 - Worker’s Comp Settlements
 - Investment Decisions
- After decades of bafflement, I began to formalize my observations into research with help from an SOA grant.
- While working on modifying the classical utility function for actuarial purposes, I happened upon some of the works of D. Kahneman and A. Tversky. It changed in my research, by incorporating a predictable psychological aspect of decision-making to “utility,” which led to what I call a “preference function.”

Behavioral Economics

- Relatively new field
- Combines psychology and economics
- Studies why people make (irrational) economic decisions instead of acting like “econs”.
- Predicts irrational decisions
- Regularly used in medicine, marketing, politics, public policy, and by high tech companies like Google and Facebook.

Super Zero

- Choose between:
 - A free \$100 travelers' check
 - \$200 travelers' check for which you pay \$70
- The economists say people will opt for the \$200 travelers' check.
- Actual experiments show people tend to choose the free item over a more valuable one.
- Example: Amazon's free shipping on orders of \$35 or more
- Exception: France – 1 Franc (about 20¢)

Social and Market Norms

- We have social norms and market norms
 - Social – relationships
 - Market – exchange of goods and services for money
- Changing from social to market
 - Can be offensive
 - Difficult to revert
- Keeping it social
 - Gifts (recognizing the human) vs Pay (recognize the value of the service)
- People will work harder, cooperate better, and enjoy it more when they volunteer than for pay.

Of Widgets and Women

25 widgets are randomly distributed to 5 women: Ava, Betty, Caty, Doris and Erin.
Which distribution is more likely to occur?

#1

Ava – 5

Betty – 4

Caty – 5

Doris – 5

Erin – 6

#2

Ava – 5

Betty – 5

Caty – 5

Doris – 5

Erin – 5

Observations about Human Nature

1. We tend to associate based on similarities rather than probabilities.

The Border Collie better fits our image of something that barks and has a natural tendency to herd animals than the larger class of entities in the universe. We expect the randomly distributed widgets to not be uniformly distributed.

2. Our minds associate possibilities with probabilities, and we tend to increase small probabilities and decrease large probabilities.

Since we can imagine winning the lottery, our minds turn the unimaginable 1 in a billion into an imaginable 1 in a million probability. Similarly, when considering flood insurance in the 200-year flood plane, we tend to “think” of more of a 1 in 20 chance of our house flooding.

3. We’re influenceable. The order, number and presentation of choices, impacts our decisions.

4. We anchor to prior prices and experiences.

5. We’re cognitively lazy. We will make the easiest decisions that avoid collecting information and avoid using computations. We only focus on what our brains identify as important.

6. We’re defensive (i.e. conservative). We tend to justify our mistakes rather than acknowledge them and learn from them.

Most of us who missed a question either felt tricked or felt a need to justify our answers.

Classical Utility Advantages

- Simple model
 - Easily Manipulated and Modeled
 - Aids understanding of the concepts
- “Works” (improves results) for many problems

“Generally a simple, [calibrated] actuarial model performs no worse than trained clinicians.”

- “Everyone” is using it, or at least everyone was using it.

No justification or explanation is required. Avoids criticism and “responsibility.” It has inertia.

Classical Utility Disadvantages

- Only reflects part (usefulness) of reality but fails to consider preferences
- Promotes current economic optimization of use instead of sustainability or satisfaction
- Considers the use of a single condition rather than the desirability of a path (or sequence of conditions)
- Fundamental axioms are not universally true

Utility Assumptions

- 1) In aggregate people behave rationally.
- 2) Utility is continuous.
- 3) More is better.
 - a) More Choices are better!
 - b) More Wealth is better!
- 4) The utility of increases diminishes. (Law of Diminishing returns).
Alternatively, people are risk-seekers or risk avoiders, but not both.
- 5) Utility is a function of wealth, although it may vary between individuals.
- 6) Completeness – Given two choices, a person can choose one or the other or be indifferent, but will not be unable to choose
- 7) Transitivity – if A over B and B over C, then A over C

All of these are quasi-true when considering “usefulness.”

Requirements for Rationality

- **Completeness** information
- **Cognition** – decision based on thought without emotions
- **Computational Ability** to analyze information
- **Consistency** in decisions

Are People Rational?

- Small Samples – Large Assumptions
- Sales based on payment method – Cash, check, credit card, pre-paid card, autopay
- Expected Randomness
- Pattern Seeking
- Correlation vs Causation
- Buying Lottery Tickets and Insurance
- Framing (cognitive bias based on presentation)
- Comparison
- Possible becomes Probable
- Conservatism
- Over-Rating Pain & Under-Rating Gain
- Intransitive Preferences
- Groupings
 - *In isolation? Outliers*
 - *In aggregate? The Norm*

Unlike Econs, Humans ...

- Process information imperfectly
- Are emotional
- Make decisions within a context
- Place more emphasis on the present and near future and near past
- Lack consistency
- Are lazy when it comes to thinking

(Source: Thaler and Sunstein, Nudge, 2008)

Reasoning with Irrationality

People have some generally predictable “irrational” behaviors.

- When taken in aggregate economic markets will also have some generally predictable irrational behaviors, contrary to what they may teach in business schools.
- Recognizing these logical “anomalies” as being normal and then behaving rationally offers opportunity for gains (economic, marketing, political, social, etc.)

A Marketing Example

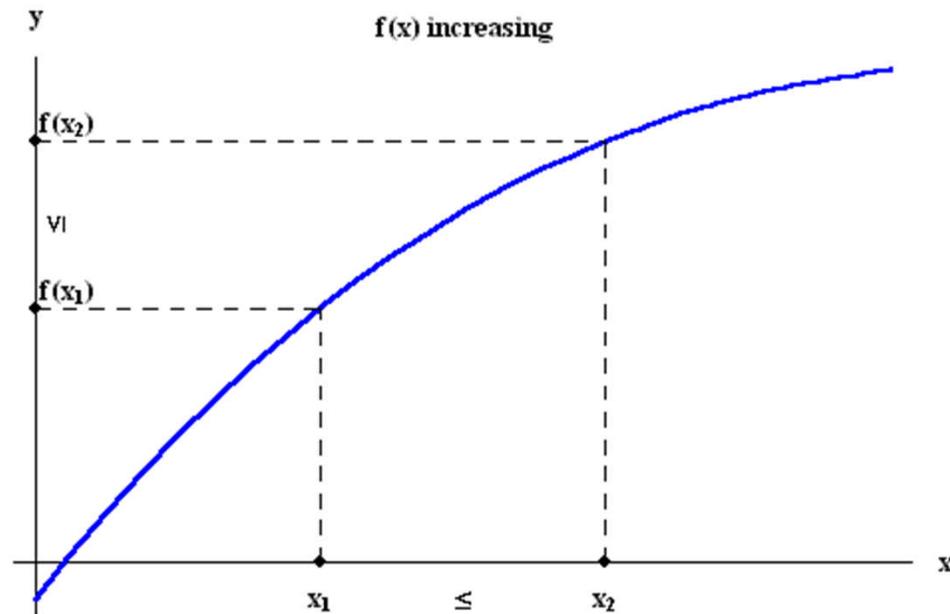
- People tend to choose medium when given the choice of small, medium or large if the medium is reasonably priced. It does not matter what the actual sizes are.
- The standard cup of coffee is 4-6 oz. and 8-10 oz. on a Keurig.
- Instead of “small, medium and large”, Starbucks offers:
 - Short (8 oz) – low portion of orders, doesn’t sound good
 - Tall (12 oz) – priced to obviously not be the best deal
 - Grande (16 oz) – what you get if you order a “medium” and the most popular size
 - Venti (20 oz) – low portion of orders
- Without the Venti, which few order, the Tall would likely be the most popular.
- We are “nudged” to buy the Grande size using Choice Architecture of Behavioral Economics.
 - Compromise Effect – we tend to choose the compromise or middle option
 - Default Effect – no involvement or action results in the default

A Stock Market Example

- **Global Blood Therapeutics (GBT) in 2017**
 - Started the year at \$14.30
 - Was on the verge of breakthroughs in gene therapy to treat sickle cell anemia and other blood diseases, but was likely to need additional operating capital
 - It had about 50 million shares outstanding
- On February 21, 2017 the price was \$28.50 and the company raised \$140 million through a secondary offering for 5 million shares at \$28. The price dropped as low as \$22.70 in response and closed the day at \$24.40
- The value could have been fairly estimated as the portion of earnings plus a proportion of the new cash:
$$\$28.50 \times (50/55) + \$140/55 = \$25.90 + \$2.54 = \$28.44.$$
- It took 6 trading days to close above \$28.44 (\$29.75 on 3/1/17).
- Buying at \$24.40 and selling at \$29.75 would have produced a return of 21% in 6 days or an annualized return of about 756%
- Reason – people over-estimate the pain of loss and dislike perceived unfairness.

Caution: This does not appear to work when a secondary offering is accompanied with insider liquidations. Thus, the dip and refinement in March.

Continuous, Monotonically Increasing, With Diminishing Returns



Is Utility Continuous?

- Continuity can be considered a simplifying illusion.
- Money is in discrete units, so wealth is not continuous.
- There are quantum conditions in actuarial science which may affect the “utility” of a state:
 - *Solvency*
 - *RBC action levels*
 - *Ratings*
 - *A policy form approval*
 - *A rate increase*
 - *Contribution rates for pension plans are typically in 0.25% increments*
 - *Hiring a new employee*

The Ticket Dilemma

- There is an event about to start where you are, and the cost is \$20 for a ticket.
- You REALLY want to go to the event.
- You have \$19 and someone offers to wager your \$19 against her \$1 based on the flip of a coin. Heads and you get her \$1. Tails and she gets your \$19.
- If the increased preference of the 20th dollar is greater than the decrease of preference of the first \$19, it is a good bet for you.

More is Always Better?

- We can process 7+/-2 thoughts simultaneously. Although more choices may be more useful, they may not be preferable.
- When faced with too many choices the decision often becomes emotional rather than rational.
- Reduced choices simplifies the decision-making process and reduces stress.
- Often unwanted additional responsibility accompanies MORE.

Is Diminishing Returns a Law?

- If it is, it should be repealed.
- Circumstances can make the desirability of a small amount disproportionately large, discontinuous utility.
- Diminishing returns is a reasonable assumption for a general model, which is sometimes incorrect.

The Real Problem with Utility

- Utility is measured without context.
- Humans make choices within a context.

“Prospect Theory” (1979)

1. INTRODUCTION

EXPECTED UTILITY THEORY has dominated the analysis of decision making under risk. It has been generally accepted as a normative model of rational choice [24], and widely applied as a descriptive model of economic behavior, e.g. [15, 4]. Thus, it is assumed that all reasonable people would wish to obey the axioms of the theory [47, 36], and that most people actually do, most of the time.

The present paper describes several classes of choice problems in which preferences systematically violate the axioms of expected utility theory. In the light of these observations we argue that utility theory, as it is commonly interpreted and applied, is not an adequate descriptive model and we propose an alternative account of choice under risk.

From Prospect Theory

- People underweight outcomes that are probable in comparison with outcomes that are certain. (Certainty effect)
- People have inconsistent preferences when the same choice is presented in different forms. (Isolation effect)
- People tend to overweight low probabilities.
- Perceived value is based on gains and losses not final assets/condition.

Mean-Variance Quadratic Optimization

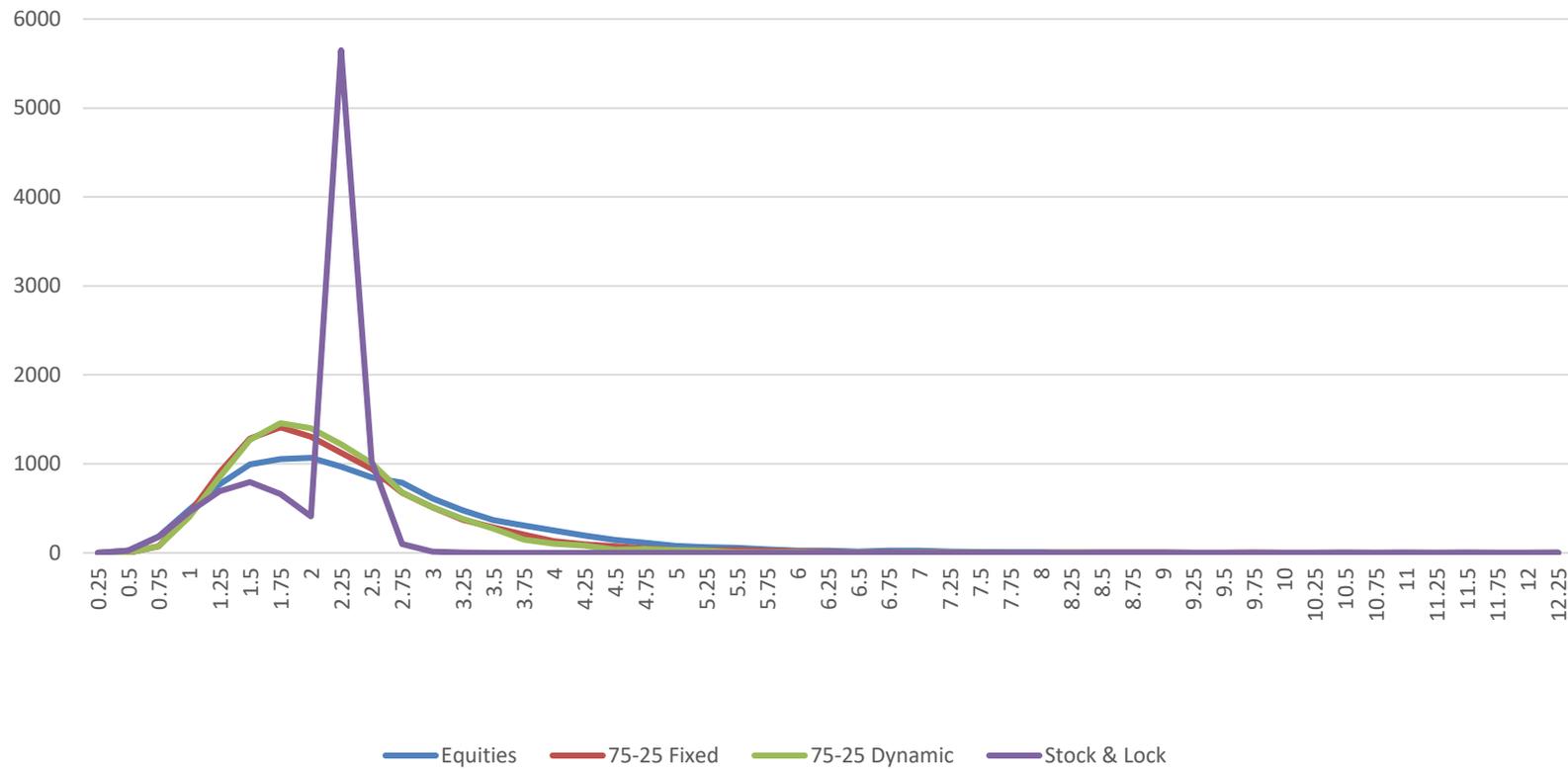
Goal: Double Investment in 10 years (7.21% Annualized)

- M-VQO gives a 50% probability of reaching the desired return

What if ...

- You need to double your money over 10 years, or something terrible will happen?
- Given the opportunity during the 10-year period, you could “lock-in” a return that guaranteed the money would double?

Strategy Distributions



Which is the best?

Depends on the investment goal:

- Maximize expected return – 100% Stock
- Most likely to reach desired return – Stock & Lock
- Maximize return for risk assumed – Stock & Lock
- *Standard deviation does not reflect skewness of returns.*
- Minimize the risk while having an expected return of at least 7.21% – 75/25 dynamic allocation.

Do We Want to Use a Function of Wealth Alone?

- Classically it is the measurement used by economists.
- Alternatively, we could consider the preference of different prospects.
 - Path
 - Story vs State
 - Immediacy (timing)
 - Stability
 - Comparisons with others (envy or “keeping up with the Jones”)

Comparison Issues

- Preferences are measured in context. It is not a choice of \$1 or \$2, but choices of total condition including wealth.
 - Lapse rates on UL are often dynamically modelled including the impact of competitor rates.
 - There is a human desire for fairness. In fact, it is more primitive than human and is seen in other mammals and in birds.
 - There also a human desire to be compassionate and to be treated compassionately.
- Preferences are affected by recent past events. (Timing)
- A preference function could include a comparison or fairness component. (Envy / Compassion)

The Human Elements

Fairness and Compassion

- Two people are in a room: Person A and Person B.
- Person A is given \$100.
- Person A must propose to split the amount with person B.
- If Person B agrees to the proposed split, both get the agreed upon amounts.
- If Person B rejects the proposed split, both leave with \$0.
- What would you offer as Person A? ... accept as Person B?

Examples of Preference Timing

- Timing Consumption
 - Buying a consumable on credit
 - Pay-day loans
- Settlements
 - Workers Comp settlements
 - Re-selling of annuities
 - Lottery payout options
 - Viatical settlements
 - Lawsuit settlements
- Market Valuations
 - Based on Quarterly Returns
 - Long-term Prospects are Highly Discounted

Another Example

- Might the company go broke ...
 - in my lifetime?
 - before I retire?
 - before I can find another job?
 - before I get my next bonus?
 - before the end of the quarter?
 - today?

How to Adjust for Time

- Money (W)

$$PV(W,t) = We^{-r(t)t},$$

where $r(t)$ is the risk – free rate for time t

However, people do not normally value wealth this way.

- Events (E)

The concept appears to fail for events.

Bankruptcy having a value of 0, would indicate the present value of future bankruptcy is always 0.

The Timing Rule

With time bad becomes better and good gets worse.

Exponential vs. Hyperbolic Discounting

Discounting the amount A_T of the T-period future into the present value A_0 :

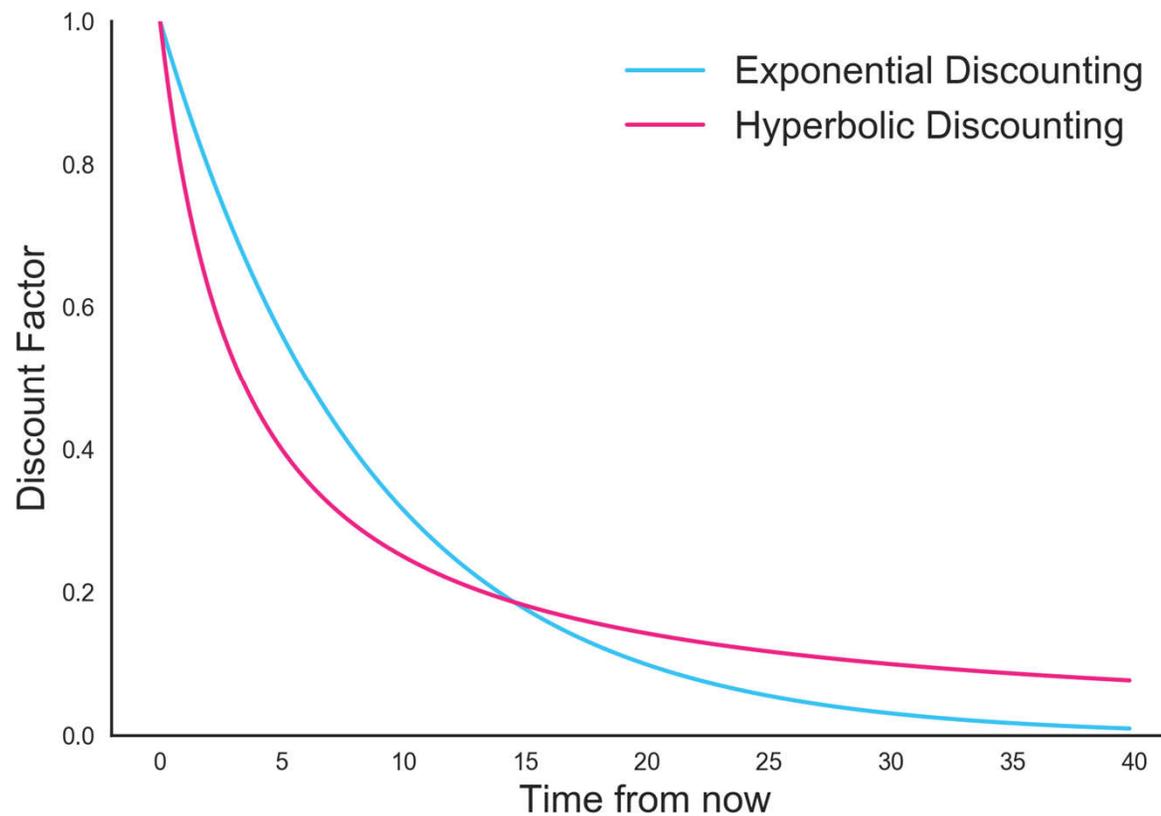
(1) Exponential discounting

$$A_0 = \left(\frac{1}{1+r} \right)^T A_T, \quad r > 0$$

(2) Hyperbolic discounting

$$A_0 = \frac{1}{1+\alpha T} A_T, \quad \alpha > 0$$

Hyperbolic Discounting



Utility of Stability

- Consider a company which has and maintains an A rating.
- Consider a company which has an A rating, that drops to B, then back up to A.
- Consider a company which has an A rating, that rises to AA, then drops back to A.

What are Utility and Preference?

- Utility is a measure of the usefulness of a single state and has traditionally been measured based on wealth.
- Preference measures the desirability of a path of states considering various stakeholders and key parameters. Instead of usefulness or optimization, it is based on satisfaction.
- An Example: Mate selection is not just based on utility, but other preferences including financial, appearance, personality, and compatibility.

I use "Preference Function" for this expanded utility function.

What is a Preference Function?

- It is a measure of the current preference of a pattern of future conditions, given past and current conditions.
- The variations in measures of the preferences of the paths is the “risk”

Parameterization

- Targets / Goals
- Wealth
- Sustainability / Stability
- Timing
- (Ir)rationality Adjustments
- Comparisons
- Past States
- Directional Changes

Stakeholders

Identify key stakeholders

– Primary

- Board of Directors/Trustees
- Officers
- Stockholders
- Policyholders
- Agents / Employees

– Secondary

- Regulators
- Rating Agencies
- Guarantee Associations
- Potential Clients

Combining Preferences

- Develop a preference function for each stakeholder
- Assign weightings for the stakeholders
 - If one stakeholder includes another's choices as part of their preference, the other's preferences would simply be given more weight.
- A multiplicative weighting could be converted to an additive weighting via logarithms, so use an additive weighting.

Potential Approaches

- Traditional Linear Program with Tweaks
 - Adjust preference values
 - Adjust weights for stakeholders
 - Adjust weights for timing
- Stochastic Modelling
- Markov Chains (Stochastic Matrices)
- Genetic Programming (Includes potential dynamic responses and changes)

A Preference Function

$$Pref(Path(t)) =$$

$$\sum_{i \in Stakeholders} W_i \sum_{T=-\omega}^{T=\omega} \frac{1}{1 + \alpha(T - t)} \times W_i(T) \times Value_i(Path\ to\ T)$$

Uses

- Futurism – Imagine the future one desires and create a path toward it. (Back-planning)
- Predictive Analytics - Predict decisions given future possible and probable states.
- Strategic Evaluations – What strategies, products, investments, incentives, will produce the most desirable results.
 - Universal Life – Policy management.

All roads lead to **Decision Making**

How does one calibrate a preference function ?

- Stochastically (initially)
- Bayesian (simplicity)
- Iteratively (dynamically)
- Using Professional Judgment

Survivor Bias

- If you interview people who played Russian roulette, they will probably tell you it was thrilling and 100% of those interviewed survived, so one might (wrongfully) conclude Russian roulette is a thrilling and safe game.
- Mutual funds and equities are usually measured based on the survivors' performance. This biases the historical returns when back-testing.
- Famous result on armaments on planes in WW II.
- Do not be too hasty to dismiss non-survivors.
 - Skewed results due to the exclusion of failures.
 - Acquired companies are sometimes excluded from historical data.

Genetic Algorithm

- Start with a population. Define “survivor” to limit bias. (Top 50%, 95% confidence level, etc.)
- Select the “survivors.”
- Elite survivors continue another generation.
- Blend survivor characteristics to develop a new population and add a “small” number of mutations.
- Repeat the process.

Through “natural selection,” a superior population will emerge. At least that is the theory.

Genetic Algorithm

- If the “survivors” are too small, the population may not thrive. You need some diversification.
- If the mutations are too numerous, they can pollute the “gene pool” and remove or disguise good “genes.”
- If the mutation are too few, the pool may not survive an anomalous event and not adjust to new circumstances.

The Future

- It took insurance regulators about 50 years to require integration of asset allocation into the actuarial opinions. Behavioral economics is about 40 years old but has more detractors than asset allocation and the efficient market concepts.
- Some companies are already employing BE, primarily in sales/marketing.
- Much work has been done on the decision to buy; I am now looking into the decision to persist or renew (policies, marriages, memberships, etc.).

Good Reads

- Thinking, Fast and Slow by Daniel Kahneman
 - Processing information vs. using rote heuristics
- The Undoing Project by Michael Lewis
 - Story of Daniel Kahneman and Amos Tversky developing behavioral economics
- Guns Germs and Steel by Jared Diamond
 - An explanation of why and how civilizations expand or are overtaken
- The Selfish Gene by Richard Dawkins
 - A theory of social biology suggesting our genes seek self-preservation
- The Brain: The Story of You by David Eagleman
 - How you shape your brain, and how your brain shapes you
- Predictably Irrational by Dan Ariely
 - Explores drivers of decision-making