DISTILLATE CAPITAL

RATIONAL INDEX DESIGN

Behavioral Biases: Exploiting Systematic Mispricings

Summary

- While economics ultimately determine asset prices, human behavior is a key element in understanding markets and how to make better decisions.

- Humans make decisions in a "dual process" system that is divided between a more dominant, older, instinctual, and faster system and a younger, slower, more methodical system.

- Conflicts between these systems and the dominance of the emotional system over the rational system result in behavioral biases that are increasingly well documented in the expanding field of behavioral economics and in studies of brain activity.

- These biases create market mispricings that we seek to exploit in several ways:
    - We use a systematic process to minimize our own biases—like confirmation bias and herding.
    - Our process is designed to avoid "lottery stocks" which tend to be systematically overpriced.
    - We focus on companies with long-term fundamental stability where we think the odds of outperformance are more favorable.

Our process seeks to exploit behavioral biases by foregoing some large outperformers, avoiding even more large underperformers, and capturing a disproportionate share of stocks that modestly beat the market.

Behavioral Economics and Market Inefficiencies

The field of behavioral economics has identified a myriad number of behavioral biases that affect human decision making. There is an increasingly rich body of work in the field that in essence shows how humans do not act like robots, as many economic models and investment theories assume. Behavioral economics is also gaining wider acceptance and acclaim with Daniel Kahneman, Robert Shiller, and Richard Thaler all recently receiving Nobel Prizes.

For investors, behavioral biases can undermine our decision making if we fall victim to them. At the same time, however, they can create opportunities in financial markets for investors who are able to exploit them. To understand these biases, and more importantly, how to take advantage of the mispricings they create, it is first necessary to understand their origins and why they are likely to persist.

The Elephant and the Rider

Behavioral economists and psychologists generally agree on a "dual-process" view of human behavior. This consists of two separate systems for decision making. The first is fast-acting, more emotionally-driven, and can operate without conscious thought. The second system is slow, rational, and conscious.[1] Sometimes these two decision-making systems are framed as instinct versus intellect, emotion versus reason, reflexive versus reflective, or gut versus brain. Daniel Kahneman even contrasted them in the title of his famous 2012 book "Thinking Fast and Slow." The Greeks, who arrived at this viewpoint long before scientists did, referred to them as Dionysus (emotion) and Apollo (reason).[2]

This "dual-process" system of thinking was also elegantly captured in Jonathan Haidt's famous example of the elephant and the rider. As Haidt described in The Happiness Hypothesis, the elephant is the automatic system that uses gut reaction and instinct, while the rider atop the elephant is the controlled system that is slower and driven by reason. The most important element of Haidt's example, though, is that the rider can control and steer the elephant only when the elephant doesn't have desires of his own.[3] In other words, while our higher-level thinking is generally in control, it is no match for instinct and emotion when they kick in.

It is the point that the elephant wins out over the rider in a disagreement that is so crucial to understanding behavioral biases and why they are likely to persist. The explanation for this dynamic between the elephant and the rider has its origins in how we and our brains evolved as a species.

The Evolution of the Brain

Humans split from apes around 10 million years ago and gradually evolved into homo sapiens around 200,000 years ago. It was only 5,000 years ago that around half the human population engaged in farming rather than hunting and gathering and when the first writings appeared.[4] Thus, for the overwhelming majority of our existence as a species, it was our system-one decision making (the elephant) that largely kept us alive. It was only in the very recent past that higher-level thinking (the rider) became so important. Psychologists Leda Cosmides and John Tooby provide a nice summary of the implications of this history:

> "The key to understanding how the modern mind works is to realize that its circuits were not designed to solve the day-to-day problems of a modern America...Generation after generation, for 10 million years, natural selection slowly sculpted the human brain, favoring circuitry that was good at solving the day-to-day problems of our hunter-gatherer ancestors...Natural selection is a slow process, and there just haven't been enough generations for it to design circuits that are well-adapted to our post-industrial life."[5]

Cosmides and Tooby summarize the result by stating that "our modern skulls house a Stone Age mind."

The evolution is mirrored in the physiological development of a child's brain, which again highlights how our quick-thinking system can overpower our rational thinking processes. According to world renowned child psychiatrist Bruce Perry,

> "[brain development] proceeds from central brain areas located toward the bottom of the brain upward and outward, roughly following the order in which the various regions evolved. This means that the lower, more central areas are the most primitive, while the higher, outer regions mediate our most advanced functions like language. As the higher regions develop, they gain some control over the lower areas.

1 David Eagleman "Incognito: The Secret Lives of the Brain" 2011.
2 Gardner "The Science of Fear" 2009
3 Jonathan Haidt "The Happiness Hypothesis" 2006.
4 Leda Cosmides and John Tooby "Evolutionary Psychology: A Primer" 1997
5 Leda Cosmides and John Tooby "Evolutionary Psychology: A Primer" 1997

> Nevertheless, even in adults, threat or distress shifts control away from the rational, abstract thinking areas to the more decisive, rapidly acting central, lower regions. Under perceived threat we get dumber but faster, which can help us survive in a fire or when fleeing from a bad guy, but can also get us in trouble at work or in other social situations."[6]

Thus, as brains are still forming in children, the more primitive or emotional parts like the amygdala dominate much like they did with our early ancestors. Anyone who has tried to reason with an angry two-year-old is well aware of this.

But, as Perry notes, this same dynamic can take hold even in an adult brain when there is a perceived threat or other trigger for the elephant to react quickly.

Human evolution and brain development are thus at the origins of the emotional biases in our decision making today. Since these biases are so deeply rooted in human evolution, it also means that they are unlikely to change anytime soon. In other words, the elephant will continue to overpower the rider for a long time to come.

Conflicts Between Our "Fast" and "Slow" Thinking Systems Produce Behavioral Biases

Because the two systems of human decision making are not always in sync and the emotional system is more powerful than the rational system, there are a litany of ways we make decisions that are irrational in our modern world. Many of these are referred to as behavioral biases and are well documented in psychology and behavioral economics. In **Table 1**, we have highlighted a few of the most well-documented biases.

While not as neatly organized and researched as the biases described by behavioral economists, investors often refer to the dangerous sway of greed and fear. We think there is a strong overlap between these two investor-labeled emotions and many of the biases that are outlined in academic literature. We used greed and fear as categorical groupings to discuss the biases that we think are relevant to our process.

Behavioral economic researchers have identified a litany of biases that influence our decision making.

Table 1: Common Behavioral Biases

Action Bias:	The impulse to act in order to gain a sense of control over a situation to eliminate a problem. Investors can feel compelled to react to a stock price change or large market move. This may make an investor feel better about what has occurred, but can lead to a suboptimal decision.
Anchoring:	A priming effect in which people cling to an initial figure (even if it has no relation to the task at hand) and are swayed in their judgments about value. Anchoring to figures like an initial purchase price can heavily influence an investor's decision to sell a stock.
Availability or Recency Bias:	An influence on people's judgments about the likelihood of an event based on how easily and vividly examples come to mind. Investors may recall extreme stock events or returns more readily and can be overly influenced by these outliers.
Confirmation Bias:	People tend to seek out or analyze information in a way that fits with their existing thinking. Investors often decide whether they like a stock and then search for evidence to support their feeling.
Cumulative Prospect Theory:	A model of how humans actually behave that shows how we tend to overweight the likelihood of small probabilities (like winning the lottery) and underweight more likely outcomes, provide different responses based on how something is framed, and are risk seeking in certain situations, but generally loss averse and feel the pain of losses more than we derive pleasure from equivalent gains.
Endowment Effect:	The tendency to overvalue something that we own. After an investor purchases a stock, he or she may become attached to it, think it is worth more than it is, and be reluctant to sell it even if the original reasons for ownership no longer apply.
Hindsight Bias:	The tendency to look at past events with the benefit of hindsight and think they were more predictable than they were. An investor may look at an underperforming stock and think with the benefit of hindsight that they could have avoided it and will be able to in the future.
Overconfidence:	The tendency to think we are more capable than we are. Investors buy risky stocks or take on long-term performance risk by holding highly concentrated portfolios, sometimes because they are overconfident.
Self-Attribution Bias:	The tendency to attribute success or failure to personal skill rather than randomness or factors beyond one's control. This may make an investor overconfident about their abilities.

6 Bruce Perry "Born for Love" 2010

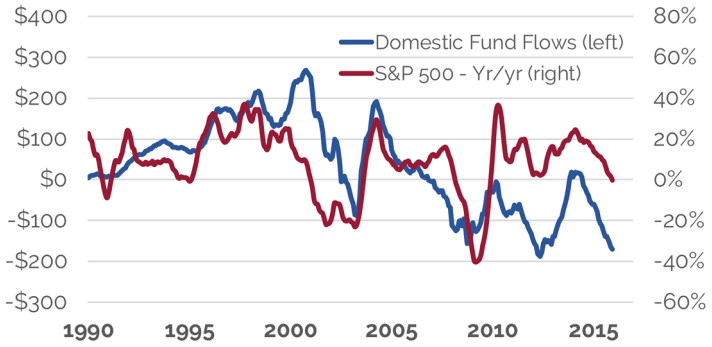
Fear

While the instinct of fear helped keep us alive for the majority of human existence, it can undermine our decision-making as investors. Fear makes us prone to panic and selling out of a stock or the market overall at the worst possible time. This is born out in numerous studies, as well as in the tight relationship between net inflows into equity funds and the performance of the stock market **(See Figure 2)**. Because investors pro-cyclically pull money out of the market when it is falling and they are fearful, but allocate more money when it is rising and they feel better, investor performance substantially lags the overall market performance on a dollar-weighted basis.[7]

Scientists have looked more closely at the impact of fear on our decision-making by tracking brain activity under different scenarios with functional magnetic resonance imaging. One study from 2001 found that winning or losing money leads to a spike in activity in the amygdala portion of our brains.[8] This is significant since the amygdala is part of the limbic system at the base of the brain that is responsible for functions of self-preservation and species preservation.[9] The amygdala is also one of the first parts of the brain to develop and is associated with the reflexive and fast-thinking "elephant" system that tends to dominate when the two decision systems are in disagreement. In other words, when we lose money, our decision-making can shift out of the more developed, higher-thinking portion of the brain and into the more emotional, lower portion of the brain. While this proclivity for making fear-based decisions may have kept us alive in prehistoric times, it can work strongly against us as investors in modern times.

Investor flows tend to be pro-cyclical and follow the market.

Figure 2: Flows Into Equity Funds vs. the S&P 500 Index



Source: FactSet, ICI

Another study showed that financial losing streaks increase activity in the hippocampus of the brain.[10] This part of the brain is next to the amygdala at the base, similarly develops early in childhood and is part of the fast-thinking system. Since the hippocampus is involved in the creation of memories of fear and anxiety, it is theorized that its activation in market losing streaks not only contributes to the panic involved in market crashes, but also explains why investors are slow to return to stocks after pulling money out during large declines.[11] Currently, the low stock weighting of millennials despite their long time horizons is thought to result from this phenomenon, and the fact their investing experiences have been dominated by financial crises.[12]

Fear is also thought to play a factor in investors' systematic overweighting of their home countries in their investment portfolios, called home bias. A study by Peter Kenning at the University of Munster in Germany showed that activity in the amygdala was triggered and associated emotions of fear arose when people considered investing in foreign markets.[13]

The anterior cingulate cortex (ACC) is another part of the brain that can lead to suboptimal, fear-based decisions. This part of the brain is constantly taking in information and looking for patterns even though there may be no conscious awareness that this is occurring. When a pattern is broken or something is out of place, the release of a hormone called cortisol triggers a feeling of fear or anxiety even before we become consciously aware of what is going on. In early humans, this is thought to have been an evolutionary advantage as it provided an early warning system for a dangerous situation. For investors, this fear trigger that stems from a broken pattern is thought to explain the high value placed on predictability and the large negative price reactions of companies that break a pattern.[14] A study by Irene Kim at the University of Michigan supports this theory as she found that the longer a pattern lasts, the more a stock may sell off after it is broken. Specifically, she found that stocks that reported earnings below expectations after previously beating earnings three times, fell 3% while a stock that had exceeded expectations in the prior eight quarters fell by 8%.[15]

7 See Dalbar's "Annual Quantitative Investment Decisions" studies and Morningstar's annual "Mind the Gap" studies.
8 Zalla, et al. "Differential Amygdala Responses to Winning and Losing: a Functional Magnetic Resonance Imaging Study in Humans" 2001
9 Swensen, "Review of Clinical and Functional Neuroscience" 2006
10 Elliott et al. "Dissociable Neural Responses in Human Reward Systems" 2000
11 Zweig, "Is Your Brain Wired for Wealth" Money Magazine October 2002
12 Liu, "Why Won't Millennials Embrace the Stock Market" Barron's July 31, 2017
13 Kenning, Mohr, Erk, & Walter "The role of fear in home-biased decision making: first insights from neuroeconomics" 2006
14 Zweig, "Is Your Brain Wired for Wealth" Money Magazine October 2002
15 Zweig, "Is Your Brain Wired for Wealth" Money Magazine October 2002

Greed

On the other side of fear is greed. And just like fear, it is deeply rooted in our brains and benefited us from an evolutionary perspective but can undermine the quality of our decisions as investors in modern times. Greed is hardwired into the way we experience pleasure through the firing of dopamine neurons in our brains. Drugs like cocaine and amphetamines, for instance, work by activating dopamine neurons and limiting the re-absorption of dopamine to prolong their influence.[16] This is also why drugs are sometimes referred to as "dope." Somewhat alarmingly, the neurological response to monetary gains is remarkably similar to the dopamine release from these drugs.[17]

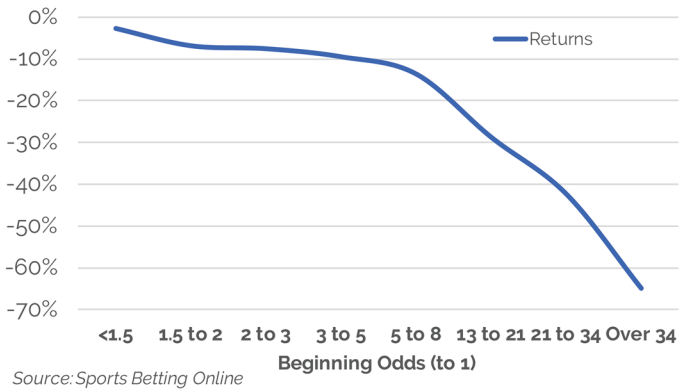
The connection to greed comes from the fact that dopamine neurons begin to fire once a reward is expected and not necessarily when it is received. When a reward is obtained and matches expectations, the dopamine response subsides. It is only if the obtained reward exceeds what was predicted that the dopamine response is increased. Since our expectations reset higher with each prediction that is exceeded, to continue getting the same positive prediction error and thus the same dopamine stimulation, the reward needs to get continuously bigger.[18] Neuroscientist Wolfram Schultz described this as a "mechanism built in by evolution that pushes us to always want more and never want less."[19] In early humans, it is thought that the positive reward of a dopamine rush and desire for more may have been helpful in not only providing a mechanism of positive reinforcement in learning, but also in driving us to venture further afield to seek food. Evolutionarily, the thinking goes this would have provided an advantage to humans or apes whose brains were not wired this way, and who may thus have struggled to secure adequate sustenance.

In addition to hardwiring our brains for greed, there are several other aspects of the dopamine response mechanism that have implications on how we make financial decisions. As rewards get larger, the dopamine response gets disproportionately bigger. This means that while we like winning, we really like winning big, which makes us especially prone to desiring longshot bets and overpaying for them.[20]

Studies of horse race betting have consistently found a longshot bias in which gamblers systematically overpay for longshot wagers such that their actual payouts are significantly worse than the net returns to wagers with more favorable starting odds.[21] Nobel Prize winner Richard Thaler wrote about this phenomenon the 1980s, but it has been subsequently studied in multiple countries and in multiple different types of betting, all with similar results.[22,23] One recent examination of 10 years of data in the U.K. and Ireland mirrored the original Thaler results and showed net returns to longshot wagers being substantially more negative than the net returns to wagers with more favorable starting odds **(See Figure 3)**.

Horse wagers show a systematic longshot bias in which gamblers overpay for wagers with low starting odds..

Figure 3: Returns on Horse Wagers by Starting Odds



Source: Sports Betting Online

Studies have also found that when a reward is less likely, the dopamine response is larger and the neurons fire for longer.[24] This means that we actually derive pleasure from taking risk in some situations. The ubiquity of gambling and lotteries in societies across the world are powerful reminders that this is the case as people knowingly accept negative expected net returns out of the hope of a large win or the exhilaration of playing. A study by Strait and Hayden found that even monkeys exhibit this behavior and produced a larger dopamine response to and preference for risky rewards compared to safe rewards of a similar size.[25] This can also push us to riskier longshot investments over less exciting, safer ones.

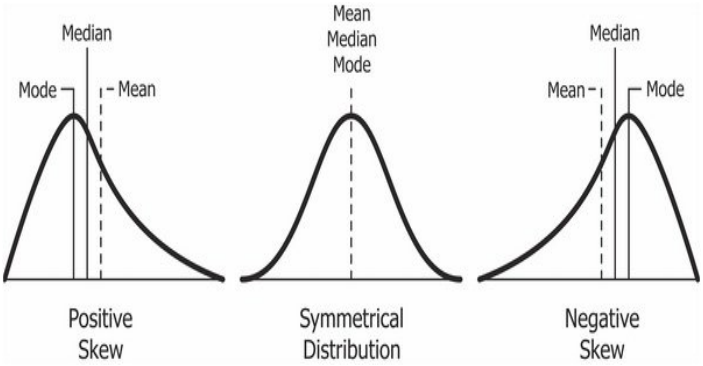
There is also a neurological influence from the skewness of a return distribution. The same study that looked at the dopamine responses of monkeys to different rewards identified a dopamine-based preference for positive skewness, which is a distribution that has a small chance of a large reward but a lower median reward **(See Figure 4)**. Imaging studies of human brains

16 Schultz, Dayan, Montague "A Neural Substrate of Prediction and Reward" 1997
17 Breiter, Aharon, Kahneman, Dale, & Shizgal "Functional Imaging of Neural Responses to Expectancy and Experience of Monetary Gains and Losses" 2001
18 Schultz "Dopamine Reward Prediction and Error Coding" 2016
19 Schultz "Dopamine Reward Prediction and Error Coding" 2016
20 Zweig, "Is Your Brain Wired for Wealth" Money Magazine October 2002
21 Thaler & Ziemba "Parimutuel Betting Marksts: Racetracks and Lotteries" 1988
22 Snowberg and Wolfers "Explaining the Favorite-Long Shot bias: Is It Risk-Love or Misperceptions" 2010
23 Berkowitz, Depken, and Gander "A Favorite-Longshot Bias in Fixed-Odds Betting Markets: Evidence From College Basketball and College Football" 2016
24 Zweig, "Is Your Brain Wired for Wealth" Money Magazine October 2002
25 Strait and Hayden "Preference Patterns for Skewed Gambles in Rhesus Monkeys" 2013

have found a similar hard-wired preference for positive skewness.[26] This also indicates a neurological preference for longshot investments.

Humans exhibit a neurological preference for positive skewness.

Figure 4: Examples of Skewness



Because of this hard-wired desire for large payoffs and skewed distributions, we favor longshot investments and are prone to overpaying for such stocks with lottery-like attributes just like we do in wagering on horses. Academic studies of "lottery stocks" have generally found that because investors are prone to overpaying for the potential for large rewards, these stocks as a group tend to underperform.[27] One recent study used the preference for "lottery stocks" to explain the low beta anomaly in which lower beta stocks outperform over the long-term despite being less risky. Investors' desire for positively skewed, lottery-like returns have also been used to explain the significant underperformance of initial public offerings (IPOs)[28] and distressed stocks.[29]

One final element of the way our reward mechanism works is that it pushes us to favor immediate payouts. Studies have confirmed that the longer we wait for a reward after the initial signal of expectation, the more the dopamine rush begins to fade. This is called temporal or hyperbolic discounting due to the rate at which the dopamine response fades.[30] This is closely connected to the behavioral bias called hyperbolic discounting in which people strongly favor immediate rewards. For example, someone might prefer $100 today over $120 in one month but when framed differently, would favor $120 in 13 months over $100 in 12 months.[31] This means that not only are we hardwired to be greedy and favor longshots, but we want the payoffs immediately. We think this contributes to the focus on short-term price moves and overemphasis on quarterly earnings reports over long-term fundamentals.

Industry Practices, the Media, and Herding Exacerbate Biases

There are also a variety of external factors that can exacerbate the biases to which we are already predisposed.

First, incentive structures at investment firms can lead investors to favor lottery stocks. Compensation may be structured such that one or two large winners will reap substantially greater rewards for an analyst than a number of more modest outperformers. In addition, individual analysts generally have only a few stocks in an overall portfolio and so may want to make those positions "count" by including stocks they think have dramatically more upside. All of this would serve to exacerbate the lottery stock bias to which we are already predisposed.

Second, the use of volatility as a risk measure can exacerbate fear-based decision-making. If a stock falls sharply, its volatility will spike. If a portfolio manager uses a risk tool that is based on volatility or is targeting an overall portfolio beta, he or she may be forced to sell the stock if it trips a volatility trigger, or may need to sell the stock to keep the overall portfolio's weighted-average beta at a targeted level. The growing emphasis on such metrics may be intensifying the impact of fear-based biases.

Third, to attract attention and get viewers or readers, the media loves to stoke our fear and greed. Regarding greed, stocks or investments with stratospheric prior gains like bitcoin or technology stocks in the late 1990s create obvious excitement and capture attention. Such coverage can play on an investor's greed and lead him or her to jump into an investment at exactly the wrong time. One of our favorite examples of the media stoking greed and the desire for lottery-like big payouts was a story on Fox News that featured a "lottery expert" and encouraged people to buy as many lottery tickets as they could afford to increase their chances of winning an $800 million jackpot **(See Figure 5)**.

The media and financial commentators also love to play on our fear. Analysts predicting the next market crash are frequently featured in the media as a financial version of the "if it bleeds, it leads" publishing motto. Firms or analysts offering investment advice also often compete for the attention of institutional and other investors through fear. Because of the hardwiring in our brains, this strategy works frustratingly often.

26 Burke & Tobler "Reward Skewness Coding in the Insula Independent of Probability and Loss" 2011
27 Barberis and Huang "Stocks as Lotteries: The Implications of Probability Weighting for Security Prices" 2006
28 Ritter "The Long-Run Performance of Initial Public Offerings" 1991
29 Campbell, Hilscher, Szilagyi "In Search of Distress Risk" 2008
30 Koayashi and Schultz "Influence of Reward Delays on Responses of Dopamine Neurons" 2008
31 Frederick, Loewenstein, and O'Donoghue, "Time Discounting and Time Preference: A Critical Review" 2002

The media often caters to our greed to attract attention and viewership.

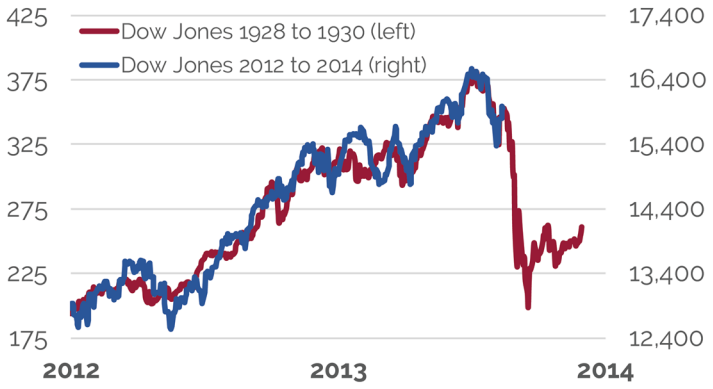
Figure 5: An Example of Media Playing on Our Greed

One tactic among such prognosticators is to overlay a chart of the current market price moves with a similar looking one that involves a crash. Exactly such a chart was making the rounds in early 2014. It showed a remarkable pattern between the market that year and the price moves of the market leading into the great depression and gave the impression that a market crash was imminent **(See Figure 6)**. Even knowing in hindsight that no such crash occurred, the chart still scares us. But when the axes of the chart are not manipulated, and both price lines are indexed to one, the apparent relationship disappears and so too does the imminent-seeming crash **(See Figure 7)**.

Lastly, herding can exacerbate and compound other behavioral biases. Herding is an essential survival tool and has been observed across a variety of species in the animal kingdom. But the benefits of herding from an evolutionary perspective do not translate favorably into economics. Studies have found that humans are more likely to make an investment if it is popular as the section of the brain involved in reward-processing shows increased activity when a stock is well-liked by other humans.[32] We are therefore prone to piling into an investment that is doing well irrespective of its valuation. Conversely, facing a change in perception, we are also likely to rush as a group for the exit and may severely depress the valuation of a stock or the overall market in the process. This effect can cause stocks or even entire asset classes to become significantly divorced from their long-term fundamentals.

In one example of a strategist attracting attention through fear, a price chart of the market crash in 1929 was overlaid on the 2014 price chart.

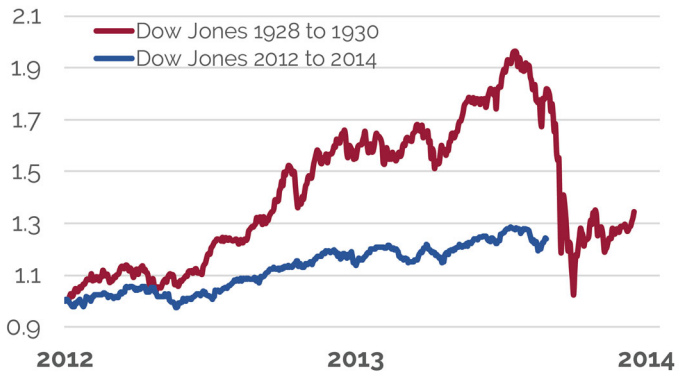
Figure 6: Dow Jones Index 2014 vs. 1929



Source: FactSet

When both price charts are indexed and more properly compared, the relationship and seemingly imminent 2014 crash disappear.

Figure 7: Dow Jones Index 2014 vs. 1929 Indexed to 1



Source: FactSet

32 Burke & Baddeley "Striatal BOLD Response Reflects the Impact of Herd Information on Financial Decisions" 2010

Manifestations of Behavioral Biases in Financial Markets

Given the litany of behavioral biases, their strong rooting in our neurology, and the potential for external factors to exacerbate them, it is no surprise that financial markets sometimes behave erratically and irrationally. Most notably, financial bubbles have existed for as long as there have been markets in which to create them. **Table 2** highlights some of the more notable bubbles.

It is also notable that even some of the most brilliant economists (including the very ones who advanced the idea that markets are perfectly rational) have fallen victim to behavioral biases. Harry Markowitz received a Nobel Prize for creating modern portfolio theory—a highly mathematical framework to analyze the tradeoff between risk and return in order to maximize expected return at any given level of risk. But when asked about his own investment allocation, Markowitz replied, "I should have computed the historical co-variances of the asset classes and drawn an efficient frontier. Instead, I visualized my grief if the stock market went way up and I wasn't in it—or if it went way down and I was completely in it. My intention was to minimize my future regret. So I split my contributions 50/50 between bonds and equities."[33] Quite an admission indeed.

Fischer Black, another legendary economist and proponent of the theory that markets are rational and efficiently priced, offered a definition of efficiency that seems to leave ample room for behavioral biases. He wrote, "we might define an efficient market as one in which price is within a factor of two of value, i.e., the price is more than half of value and less than twice value...By this definition, I think almost all markets are efficient almost all of the time. 'Almost all' means 90%."[34] Instead of each stock price being perfectly accurate each day, Black's definition of efficient means that 90% of the time the market overall could double in price or fall by half and still be properly priced. This is a definition that does not appear inconsistent with the idea that biases can lead to exploitable mispricings.

Asset bubbles have been present for as long as markets have existed.

Table 2: Famous Bubbles

Tulips (1619 to 1622):	In Holland, tulips became symbols of wealth and traded at extraordinary prices—as much as 20x the annual salary of a skilled craftsman.
South Sea Bubble (1720):	Shares in the British joint-stock company surged from £130 in February to £1000 in August of 1720 after the British government granted it a monopoly to trade in South America (even though Spain dominated the region).
Railway Mania (1830s & 1840s):	A period involving two bubbles and busts in the 1830s and 1840s in which shares of companies operating recently-invented railroads rose to enormous levels on forecasts for extraordinary future demand.
Florida Land Boom (1920s):	Land prices and development in Florida soared during the 1920s amid a speculative mania that fizzled out in the mid 1920s as land flippers eventually struggled to find long-term buyers.
U.S. Stocks (1923 to 1932)	Supported by margin buying and a speculative fervor, the Dow Jones Industrial Index climbed from 66 in 1921, to 376 in September of 1929 before falling back to 44 in 1932.
Nifty Fifty (1960s & 1970s):	Fifty fast-growing and highly reputable companies became known as the Nifty Fifty. Given the growth and quality, valuation for these stocks was thought to be less relevant and in 1972, their P/E of 42 dramatically exceeded the S&P 500 Index multiple of 19.
Gold (1975 to 1982):	The gold price soared from $35 in 1970 to $850 in 1980 before dropping to under $300 per ounce in 1982.
Japan Real Estate (1980 to 2003):	The price of urban land in Japan's largest cities rose nearly six-fold in real terms between 1982 and 1990 before falling around 60% by 1995. Land prices reached 40x those in London on a price per square meter basis.
U.S. TMT Bubble (1994 to 2002):	Amid the tech, media, and telecom frenzy, the NASDAQ Index price soared from around 750 in 1995 to over 5,000 in 2000 before plummeting back to a low of around 1,100 in 2002.
U.S. Housing (2000 to 2007):	Fueled by a massive surge in mortgage debt and reckless lending, home prices in the 10 largest cities in the U.S. rose by 125%, per the Case-Shiller 10 Index, from 2000 to 2006 and then plunged by 35% from 2006 to 2012.
China Stocks (2007 & 2015):	China's A shares surged from around 1,100 in 2005 to around 6,400 in 2007 only to plunge to 1,800 in 2008. The market rocketed up again in 2015 from around 2,200 to over 5,400 before falling back to 2,800 in 2016.
Cryptocurrencies (2014 to 2017)	During a cryptocurrency frenzy, Bitcoin rose from $5 in 2012 to nearly $20,000 in 2017. It plummeted back to around $6,000 in 2018.

33 Zweig "Your Money and Your Brain" 2007

34 Black "Noise" 1986

How We Exploit Mispricings Created by Behavioral Biases

If the evolutionary hardwiring of our brains causes behavioral biases that result in stock market mispricings, how do we avoid making those mistakes and instead capitalize on them? There are three key ways in which the design of Distillate Capital's Fundamental Stability Value portfolio seeks to do so.

First, by employing a systematic approach, we are able to avoid emotional biases like overconfidence, confirmation bias, and recency bias. We are thus unable to get caught up in an exciting story and buy a stock that is not attractively valued in our framework, no matter how much we might feel emotionally inclined toward it. If a stock that we own has outperformed and no longer looks attractive, our process causes us to exit. Similarly, if holding in our portfolio suffers from an erosion in its fundamental outlook and the valuation becomes less attractive, we exit regardless of our emotions towards it.

Second, our process is designed to exploit the lottery stock bias in which investors tend to pay too much for stocks with the potential for big near-term payoffs. Those stocks as a group have been shown to chronically underperform market averages. By combining measures of fundamental stability, balance sheet quality, and valuation, we seek to systematically avoid this group and thereby forego shares with higher probabilities of large losses. By eschewing the tails of the distribution curve of returns, we instead seek to increase our exposure to stocks with higher probabilities of more modest outcomes. Similar to the example of returns on horse wagers by starting odds, we intend to avoid the longshots where we think the cost of a ticket is mispriced in relation to the odds of winning, and instead focus on the higher probability horses that are underpriced relative to their chances of success.

Lastly, our process is designed to buy high quality companies where the long-term fundamentals are healthy but where fear-based selling in the short-term may have created an opportunity. We think picking up high quality companies at attractive prices also helps us limit our exposure to the negative tail of the distribution curve of returns while increasing our odds of having a disproportionate share of good performers.

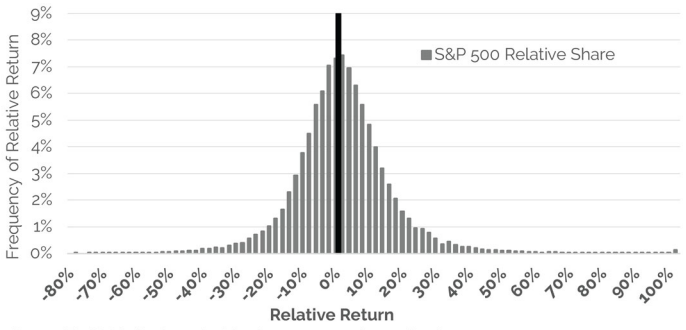
Process Evaluation

To evaluate our process along these lines, we dig below portfolio level returns and into the distribution of individual stock returns. In one of his many excellent books on investing, Michael Maubossin captured both the importance of process and the probabilistic nature of investing when he wrote, "The best long-term performers in any probabilistic field—such as investing, sports-team management, and pari-mutuel betting—all emphasize process over outcome...Because of probabilities, good decisions will sometimes lead to bad outcomes, and bad decisions will sometimes lead to good outcomes...Over the long haul, however, process dominates outcome."[35] In the same book, Maubossin also emphasized that investing is not about determining the odds of success, it is about identifying opportunities where the odds of success are mispriced. Thus, to examine whether our process does indeed skew the odds of success for the overall portfolio by avoiding lottery stocks and favoring modest outperformers where we think there are overlooked opportunity, we examined the distribution of individual stock returns for our model and compared them to those of the overall market.

Using data starting with the origination of the S&P 500 ETF in 2000, we looked at the quarterly performance of each individual stock in the index relative to the overall market in each quarter. The resulting histogram of the relative quarterly returns shows a fairly normal looking distribution curve with most stocks performing in line with the market **(See Figure 8)**. Not surprisingly, the most commonly occurring relative return is zero, which occurs just less than 8% of the time.[36]

*The distribution of quarterly individual stock returns **relative** to the overall market for the S&P 500 ETF looks fairly normal with stocks earning a zero relative return around 8% of the time.*

Figure 8: Distribution of Relative Returns (S&P 500)



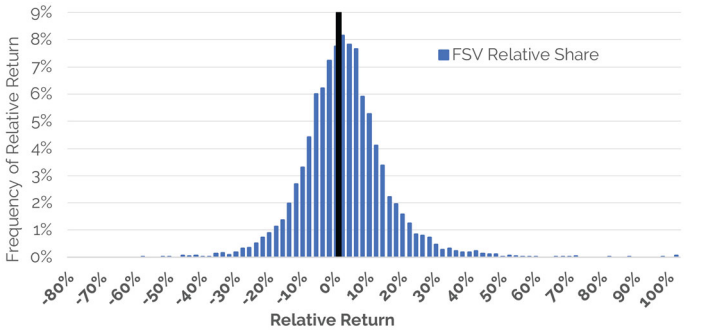
Source: FactSet (9/30/2000 to 6/30/2017; ~33,000 observations)

35 Maubossin "More Than You Know: Finding Financial Wisdom in Unconventional Places" 2006

36 Returns are presented in increments of two percentage points, so relative returns for individual stocks in the S&P 500 ETF were between -1.999% and 0% a total of 7.4% of the time and between 0.001% and 2% a total of 7.5% of the time.

The distribution of stock returns in the Fundamental Stability and Value U.S Large Cap Model is more peaked and slightly skewed positively with a larger share of modest outperformers than the overall index.

Figure 9: Distribution of Relative Returns (Modeled FSV)



Source: FactSet (9/30/2000 to 6/30/2017; ~7,000 observations)

The data contained in the nearby chart(s) contain hypothetical results of Distillate's proprietary stock selection criteria, and not actual fund performance. These data are intended for illustrative purposes, and do not reflect management fees or transaction costs, which would reduce returns. Past performance is not indicative of future results.

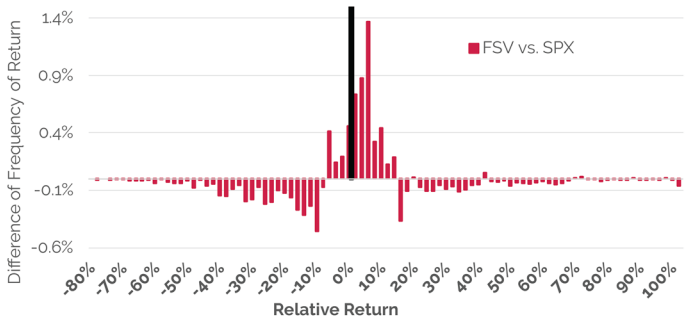
Looking at the same analysis of the relative quarterly returns of the stocks in our modeled Fundamental Stability and Value (FSV) portfolio shows a roughly similar pattern, but with several key differences: its distribution is more peaked and has a slightly narrower range **(See Figure 9)**. Again, the most commonly occurring relative return is zero, which happens a little more than 8% of the time.

The difference between the two frequency distributions is shown in **Figure 10**. At each interval on the horizontal axis, the relative return frequency of the S&P 500 ETF is subtracted from the same relative return point of our FSV modeled portfolio. The vertical bars are thus the difference in frequency at each level of relative returns. Examining the chart, it becomes clear that the FSV portfolio tends to own more stocks that modestly outperform the market in any given quarter. In the chart, this is evident by the cluster of positive vertical bars at relative returns between 0% and 20%. The highest bar, for example, shows that our model has owned stocks that outperform those in the S&P 500 ETF by between 4% and 6% per quarter, around 1.4% more frequently than the overall market. Where the blue bars are below zero on the horizontal axis, the FSV portfolio tends have fewer cases where its holdings generated the corresponding returns. This shows that while the FSV portfolio tends not to have as much exposure to those stocks generating very large relative returns in any given quarter, it is even less inclined to own shares that underperform the market by 10% or more in any given quarter.

Putting this all together in baseball terms, while the FSV portfolio tends to not hit home runs, it strikes out much less frequently and hits a disproportionately high share of singles and doubles.

Compared to the distribution of individual stock returns for the overall market, the modeled FSV fund has fewer large outperformers, but even less big losers, and a disproportionate share of modest winners.

Figure 10: Difference in Relative Returns Between the Modeled FSV Strategy and the S&P 500 Index



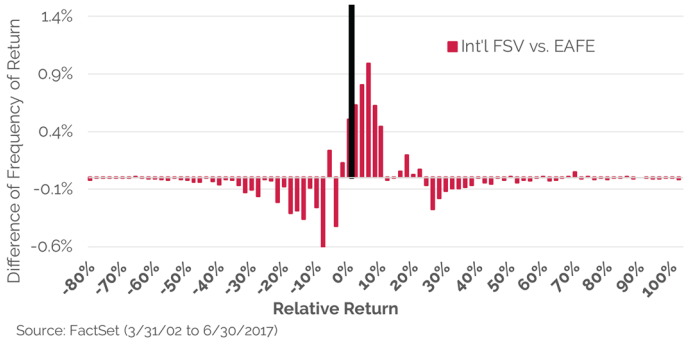
Source: FactSet (9/30/2000 to 6/30/2017)

The data contained in the nearby chart(s) contain hypothetical results of Distillate's proprietary stock selection criteria, and not actual fund performance. These data are intended for illustrative purposes, and do not reflect management fees or transaction costs, which would reduce returns. Past performance is not indicative of future results.

Importantly, when we applied the same process to the MSCI EAFE Index of developed world stocks outside of the United States, an identical pattern emerged **(See Figure 11)**. Since the human biases we are seeking to exploit are not unique to the United States, it stands to reason that behaviors and opportunities abroad should mirror those in the U.S.

The distribution of individual stock returns in the Fundamental Stability and Value U.S Large Cap Model.

Figure 11: Difference in Relative Returns Between the Modeled Int'l FSV Strategy and the MSCI EAFE Index



Source: FactSet (3/31/02 to 6/30/2017)

The data contained in the nearby chart(s) contain hypothetical results of Distillate's proprietary stock selection criteria, and not actual fund performance. These data are intended for illustrative purposes, and do not reflect management fees or transaction costs, which would reduce returns. Past performance is not indicative of future results.

Final Word

Our modeled results are consistent with our expectations. The process preserves capital in a downturn and captures pricing opportunities during more typical flat or rising markets by systematically exploiting the behavioral biases that are well documented in research. Because of the tendency for human emotion to overwhelm logic and rational thought, particularly in times of stress, we believe the causes of pricing opportunities will remain evergreen.

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