

The Music of the Spheres and the Alchemy of Finance

"You say that we go round the sun. If we went round the moon it would not make a pennyworth of difference to me or to my work." – Sherlock Holmes (from "A Study in Scarlet" by Arthur Conan Doyle)

"It doesn't matter if the cat is black or white, as long as it catches mice." – Deng Xiaoping

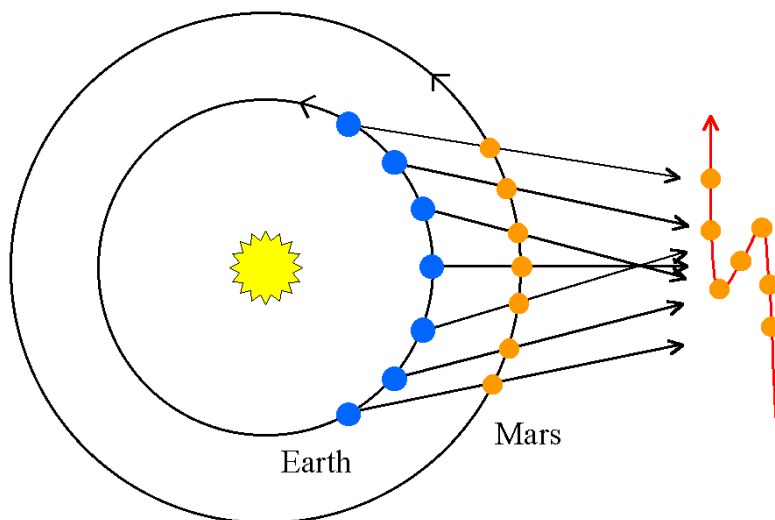
"I could float off this floor like a soap bubble if I wish to. I do not wish to, because the Party does not wish it. You must get rid of those nineteenth-century ideas about the laws of Nature. We make the laws of Nature." – O'Brien (from "1984" by George Orwell)

A few million years ago – the blink of an eye in evolutionary terms – our ancestors were roaming around some African savannah in a small band. We are still that social hunter-gatherer, for better or worse, with all the advantages and disadvantages our evolutionary heritage provides. Advantages include opposable thumbs, big eyes, and lots of neurons devoted to pattern recognition ... attributes that, among other things, make our species very competent at driving cars and playing video games. Disadvantages include relatively few neurons and no sensory organs for interpreting really large numbers or physical laws that are foreign to an African savannah ... attributes that, among other things, make our species poor theoretical astronomers.

We are excellent observers and pattern recognizers. For thousands of years, no astronomical event visible to the naked eye, no matter how minor, has escaped our attention and overwhelming need to find its pattern. But if understanding why these celestial patterns occur as they do requires a belief that the sun is an incomprehensibly large ball of hydrogen plasma 96 million miles away that warps the time/space continuum with its gravitational force ... well, it's pretty easy to understand why a heliocentric theory wasn't humanity's first choice.

For thousands of years, then, Common Knowledge – what everyone knows that everyone knows – of humanity’s place in the universe was dominated by this geocentric view, supported in the distant past by various origin myths and since 384 BC and the birth of Aristotle by the Narrative of Classical Science. Like all successful Narratives, Classical Science and Aristotelian geocentrism had a ring of truth to it (“truthiness”, as Stephen Colbert would say) and worked in concert with the interests of the most powerful political and economic entities of the day, from the Alexandrian Empire to the pre-Reformation Catholic Church. For almost 2,000 years the status quo entities of the West – whether explicitly religious such as the Catholic Church or dynastic and quasi-religious such as the Rashidun Caliphate, the Byzantine Empire, and the Holy Roman Empire – were based on a geocentric origin myth. The Narrative of Classical Science was extremely useful in efforts to maintain this myth because it allowed these political institutions to present geocentrism within the “modern” and compelling framework of Greek culture and learning, as opposed to the rather grim and ancient oral traditions of a nomadic desert tribe. Charlemagne may have famously used the sword to convert entire tribes to Christianity, but over a longer period of time Aristotle proved even more effective.

Unfortunately, however, there was a problem with the Aristotelian geocentric view of all the heavenly bodies circling the Earth in unison, creating a perfect and timeless “music of the spheres” ... the data didn’t fit the theory. Mars, for example, goes back and forth in the sky with a retrograde motion during

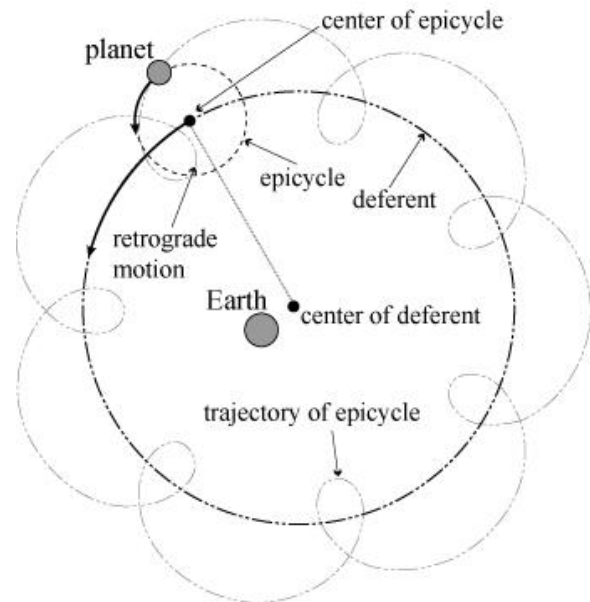


certain periods of the year, as do all of the planets to one degree or another, as opposed to a steady sweep across the sky as would be the case with a regular orbit around the Earth. Why? Because in truth both Earth and Mars go around the sun, and since Earth’s orbit is inside that of Mars, the position of Mars relative to Earth takes on a retrograde pattern when seen from Earth.

Fortunately for the Narrative of Classical Science, however, around 140 AD an Alexandrian Greek named Claudius Ptolemy figured out how to reconcile the observed astronomical patterns with Aristotelian theory by devising the notion of “epicycles” and “deferent points”.



Claudius Ptolemy (c. 90 – 160 AD)



In the Ptolemaic system, planets don’t orbit around the Earth directly. Instead, they orbit around a point in space (the epicycle center) that orbits around another point in space right next to Earth (the deferent center). The result is a flower-like orbit around the Earth for every planet, generating periods of retrograde movement as seen from the Earth.



If you ever had a Spirograph as a child (my favorite toy ever!), you’ll immediately understand Ptolemy’s theory. Basically he re-conceptualized the solar system as a giant, complex Spirograph, and through that brilliant insight the Narrative of Classical Science was saved.

Almost all of the observed data fit the Ptolemaic model well, and the theory was effective at predicting future astronomical events like eclipses and transits. Not perfect, but effective. For more than 1,000

years after his death in 168 AD, Ptolemy was the first and last word in everything to do with astronomy and astrology in both the Christian and Islamic worlds. Now that's a useful Narrative!

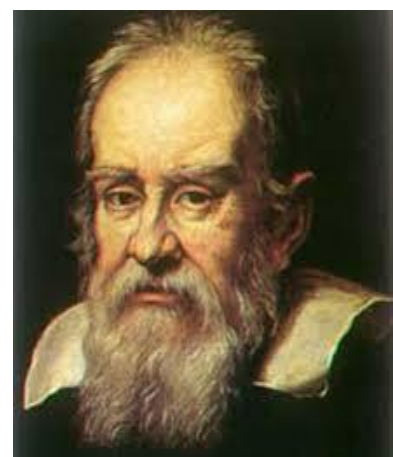
So what went wrong with the Spirograph model of the universe? In school we learn that Copernicus "discovered" the heliocentric theory of the solar system and published a book to that effect in 1543, thus launching the Copernican Revolution. The popular implication is that it was the strength of the new ideas themselves that won the day for Truth and Reason against the narrow-minded intellectual tyranny of the Church. Yeah, right. In fact, it wasn't until 60 years after Copernicus died that the Church got around to condemning his book and his theory. It took that long for his ideas to become dangerous to Rome because it took that long for his ideas to become useful to political and economic entities in Northern Europe. It also took that long because the world had to wait for Kepler and Galileo to improve on Copernicus so that his theory fit the observed data more comprehensively AND more effectively than Ptolemy.



Nicolaus Copernicus (1473 – 1543)



Johannes Kepler (1571 – 1630)



Galileo Galilei (1564 – 1642)

I want to focus on that last point for a minute. The original heliocentric model that Copernicus developed was a lot simpler than the Ptolemaic model, but it didn't work very well ... if you wanted to predict an eclipse or the date that Easter would occur in some future year, you were still better off using the good old Ptolemaic tables. To make the observed data fit his model, Copernicus ultimately had to take the same Spirograph approach that Ptolemy had used 1,400 years earlier, complicating his original ideas enormously by introducing epicycles and the like. The problem for Copernicus was that he was hooked on the idea of circular orbits. It wasn't until Kepler modified the heliocentric model with the idea of elliptical planetary orbits in 1615 that everything fell into place with a single simple theoretical

structure. And it wasn't until Galileo made his telescopic observations of the phases of Venus in 1610 that the Copernican model accounted for observed facts that the geocentric model could not possibly support.

In the history of Ptolemy and Copernicus we see the three necessary and sufficient conditions for a "paradigm shift", which is just another term for an abrupt change in the Common Knowledge surrounding some socially-constructed phenomenon:

- 1) new data observations that fit the new paradigm better than the old paradigm;
- 2) new ideas that create a simpler and more fundamental structure for the new paradigm relative to the old paradigm;
- 3) political and economic entities that come to see their self-interests better supported by the new paradigm than by the old paradigm.

I think it's possible that we are on the cusp of just such a paradigm shift within the investment world, away from a narrow-minded faith in the power of Modern Portfolio Theory and its econometric foundations, and towards a more inclusive view of markets that incorporates an appreciation of historically-conditioned behavior as well as patterns of strategic decision-making under uncertainty.

Maybe that's just wishful thinking on my part, but the necessary and sufficient conditions for change are present, including the realization by powerful political and economic entities that the current system ... well, it just ain't working. Structural changes in markets (see "[How Gold Lost Its Luster](#)") are eroding business models left and right. The collapse in trading volumes is poison to anyone who worships at the altar of Flow, like bulge bracket sell-side firms, and rampant disintermediation is death to gatekeepers like fund-of-funds and consultants. I mean, is your view on whether to buy or sell Apple really going to be influenced by the umpteenth sell-side model of Apple's gross margins? Do you really need a consultant to tell you how to buy market exposure through ETF's?

Of course, the same thing happened the last time we suffered through a multi-year investing environment of alpha scarcity and beta dominance, back in the 1930's. Market makers and investment intermediaries dropped like flies throughout the decade, a process that – like today – was accelerated by sharp shifts in the regulatory environment (Glass-Steagall in 1933, Dodd-Frank in 2010). In fact, it really wasn't until the mid-1950's that the financial services industry began to grow dramatically again, not coincidentally with the introduction of Modern Portfolio Theory in 1952 and the expansion of retail

brokerages (especially “the thundering herd” of Merrill Lynch) onto every Main Street in the U.S. These twin Narratives of the 1950’s – Everyman Stock Ownership and Modern Portfolio Theory – drove an investment paradigm shift that created modern Wall Street.

I don’t know for sure what the 21st-century equivalents of Everyman Stock Ownership and Modern Portfolio Theory will be for Wall Street, or how and when the associated Narratives will develop. But there is no more important question that Wall Street needs to answer in order to reinvent itself (again), and if I had an hour of Gary Cohn’s time this is what I’d want to talk about. I think that Epsilon Theory is a good place to start in evolving Modern Portfolio Theory into something more useful, and I think that there is already an established set of people and practices that can push paradigmatic change forward: traders and technical analysis.

Like many investors trained with a fundamental bias, for years I pooh-poohed the very idea that technical analysis had anything to offer a “true” investor. Technical analysis was the province of traders, and to call someone a “trader” was about the worst insult you could deliver in these circles. It was an entirely pejorative term, and it meant that you weren’t as serious or as thoughtful as a praiseworthy “long-term investor”. I was foolish to hold this bias, and I was a less effective portfolio manager for it. My job as a portfolio manager was to make money for my clients – to catch mice, as Deng Xiaoping would put it – not to make money in a theoretically pure way. If technical analysis could have helped me catch more mice – and it could – then I should have embraced it, not dismissed it out of hand.

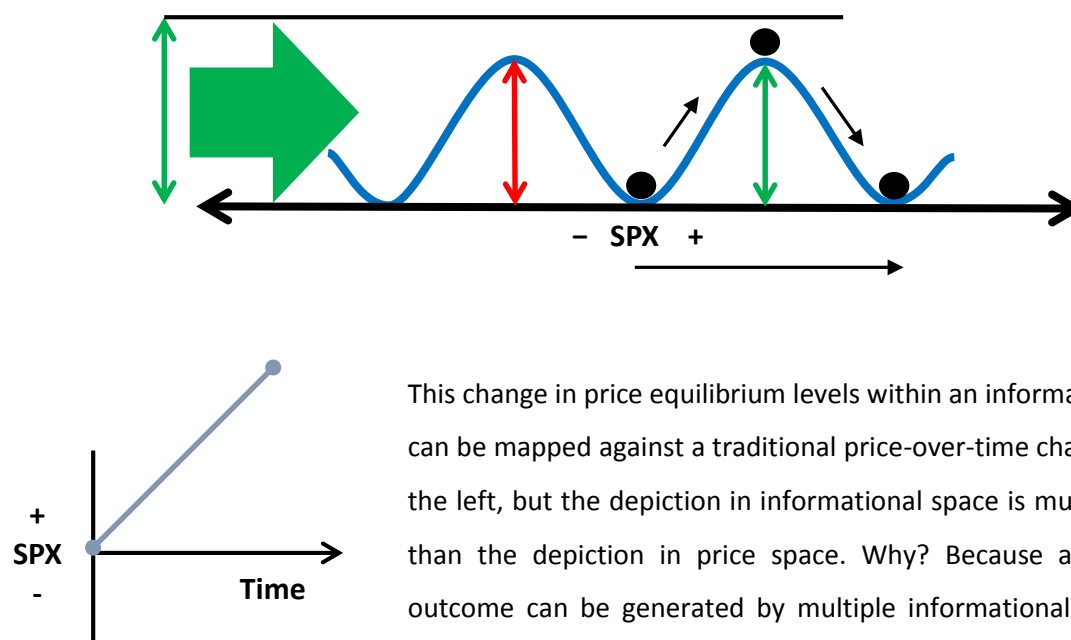
Technical analysis is, at its heart, behavioral analysis, and as such is prime real estate to build a new investment paradigm that incorporates game theoretic behaviors.

Now don’t get me wrong ... there are HUGE problems with the application of technical analysis today. Technical analysis requires a Copernican Revolution. By that I mean it needs to be re-conceptualized away from the Spirograph models and the naïve empiricism that currently dominate the effort. Not because the current conceptualization is a failure, any more than the Ptolemaic conception of the solar system was a failure. The world functioned quite well for 1,400 years using Ptolemaic tables to predict the position of planets and stars, thank you very much. But technical analysis could accomplish so much more, both in terms of accuracy and of scope, if it were put on a more solid theoretical foundation. If you try to launch a rocket while believing in a geocentric model of the universe, you’re going to fail. I think that technical analysis could, in fact, “launch a rocket” in that it could drive a paradigm shift in how

we think about and operate effectively within modern markets, **but only if we change the conceptual center of the trading universe from Price to Information.**

When you talk with experienced options traders, it seems as if they can “see” securities in terms of volatility space, not the two-dimensional price-over-time matrix that most investors and traders use as their lens. What I want to suggest is to see ALL securities in terms of what I will call “information space”. In prior work (“[Through the Looking Glass](#)”) I laid out this methodology in detail, so I won’t repeat that here. The basic idea, though, is to describe a point in time for a security in terms of the information required to move that security’s price from its current equilibrium to a higher or lower equilibrium.

Here, for example, is a simplified two-dimensional informational scenario for a broad market, say the S&P 500, with the black ball representing the current equilibrium price level for that market and the height of the trough walls representing the informational strength of the current equilibrium level. This is the informational surface. To make the ball “roll” to a new higher equilibrium level requires a strong enough signal (represented by the green arrow) to get over the right-hand trough wall, and vice versa for the market to go down. The informational surface plus the new information signal combine to create an informational scenario.



This change in price equilibrium levels within an informational scenario can be mapped against a traditional price-over-time chart as shown on the left, but the depiction in informational space is much more useful than the depiction in price space. Why? Because any given price outcome can be generated by multiple informational scenarios, but any given informational scenario will generate one and only one price outcome. Just knowing the price outcome gives you little idea of how or why that price outcome arose. But if you know the informational scenario you know both the unique price outcome as well as how it

came to be. An informational scenario can predict price, but a price can neither predict nor explain afterwards an informational scenario.

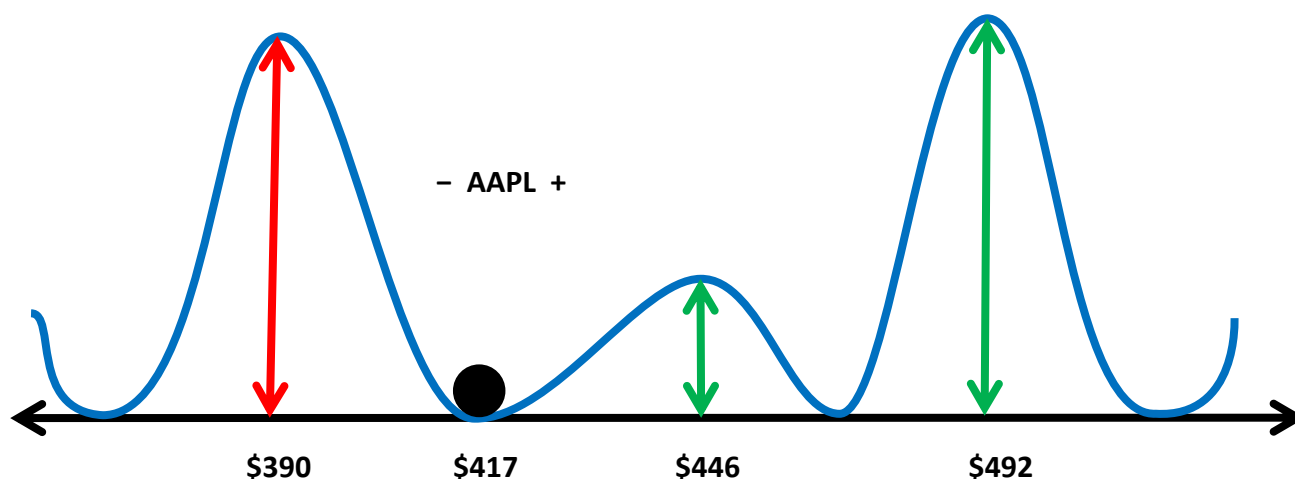
Seeing the market in terms of information space will NOT tell you whether the market is going up or down. It shows you how the market is likely to react to new information, and it gives you tools for evaluating the potential market impact of new information. Epsilon Theory is both a methodology (a toolbox for evaluating observed data) and a theory (a conceptualization of observed data). Methodologies and theories are neither true nor false, only more or less useful than alternative toolboxes and conceptualizations, and I have no doubt that Epsilon Theory is not terribly useful for some investment strategies. Sherlock Holmes didn't care whether the Earth went around the sun or the other way around because it made "not a pennyworth of difference" to his life or his work, and the same is probably true for Epsilon Theory and, say, private equity investing.

But here's an example of how a common dialog between traders and portfolio managers can be much more useful when reformulated in informational terms.

When a trader tells a portfolio manager that there is "resistance" at a particular price level, and "support" at another, he is making a statement about informational structures created by historical patterns of price movements. This is true regardless of the specific methodology used to determine these resistance and support levels – Bollinger Bands, Fibonacci Series, MACD, whatever. For example, here's a MACD price chart for Apple that I've marked with hypothetical resistance and support levels (NB: I have no idea whether these levels are methodologically accurate, and it really doesn't matter for the point I'm trying to make):



And here's that same chart expressed as an informational surface:



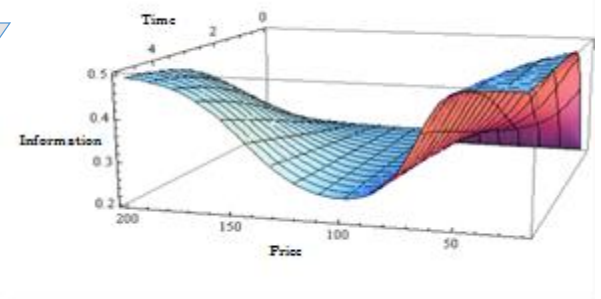
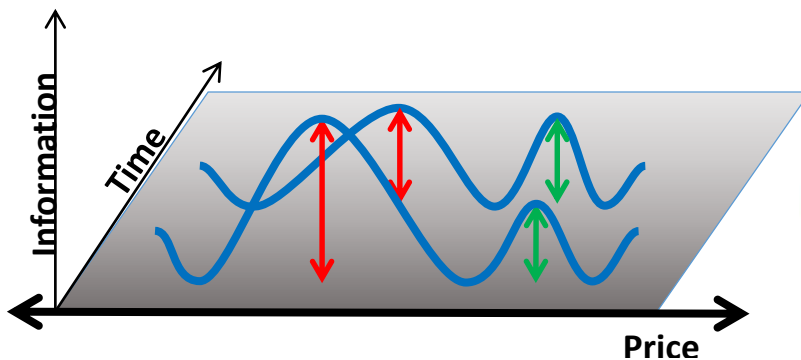
The advantage of the informational surface expression over a price chart is that it is (potentially) more accurate, more comprehensive, and more understandable without being more complex.

An informational model is potentially more accurate because the resistance and support levels are not binary or categorical thresholds (resistance vs. support, strong vs. weak) but are variable representations of their inductively derived informational strength or weakness. Rather than simply saying, “there’s resistance at \$446” it’s possible to say “it will require 0.6 generic bits of information to get over the resistance at \$446 and 1.8 generic bits of information to get over the resistance at \$492.” And because there are tools to measure the informational strength of new information, it’s possible to estimate the likelihood that this piece of new information will be sufficient to pierce the \$446 resistance but that piece of information will not.

An informational model is potentially more comprehensive because non-price informational barriers can be incorporated directly into the analysis. One of the biggest weaknesses of technical analysis as it is currently constituted is that it only “sees” informational signals based on historical price outcomes. By re-conceptualizing price as information, other important types of information, such as public statements and macro data announcements, can be plugged into the same inductive analytic framework. There’s an enormous amount of intellectual firepower embedded in technical analysis that is underutilized because it is only applied to price data. Information theory provides a common language for every type of signal,

and by “translating” all sorts of signals into the language of information we can significantly expand the scope of powerful inferential tools that fall under the rubric of Big Data.

An informational model is potentially more understandable because the dimension of time can be incorporated more easily, or at least more intuitively, into the analysis. All forms of technical analysis are based on some flavor of time series regressions, so it’s not that time is ignored. But by including it graphically as an additional dimension, you can create the equivalent of a volatility surface, which makes it much easier to “see” the informational dynamics at work.



What I’m suggesting – to treat patterns of price data as an important informational signal within a broader theory of behavioral finance – is not original to me. **The Copernicus of this story is George Soros, and the application of game theory to markets has its first (and in many ways still best) expression in his magisterial 1987 book, *The Alchemy of Finance*.** I am not going to attempt any sort of summary of the book here, because it defies easy summary. It is, as Paul Volcker (!) writes in his Foreword to the 2003 edition, “an honest struggle by an independent and searching mind to break through a stale orthodoxy with new and meaningful insights into financial and human behavior”, which



The Flammarion engraving (c. 1888, author unknown)

is just about the highest praise an author can receive. I’ll just add that even though Soros does not frame his core ideas such as “reflexivity” in terms of formal game theory, there is no doubt that this is his intellectual home. Everything that Soros writes about the behavior of markets can be expressed, sometimes more effectively but usually less, as a game theoretic construct.

Reflexivity is the best known of Soros's core concepts, but also tends to be misunderstood. Rather than repeat Soros's own words or define it with the language of game theory, let me give you an example of reflexivity as a conversation that happens in one form or another hundreds of times a day, every day, all around the world.

PM: Hey, why is XYZ down 3% all of a sudden?

Trader: I don't know. There's nothing on Bloomberg. Let me ask around.
[2 minutes later]

Trader: Nothing on chat. All the desks are calling around trying to find out what's going on.

PM: Is there a conference or something where management is talking?

Analyst: I don't think so. I tried calling IR, left a message.

PM: Well, somebody must know something. I hate this stock ... it could go down 10%. Sell half the position and put a tight stop on the rest. Gotta manage the risk. Let me know if either of you hear anything.
[30 minutes later]

Trader: We got stopped out. You're flat.
[2 days later when XYZ has fully recovered to its original price]

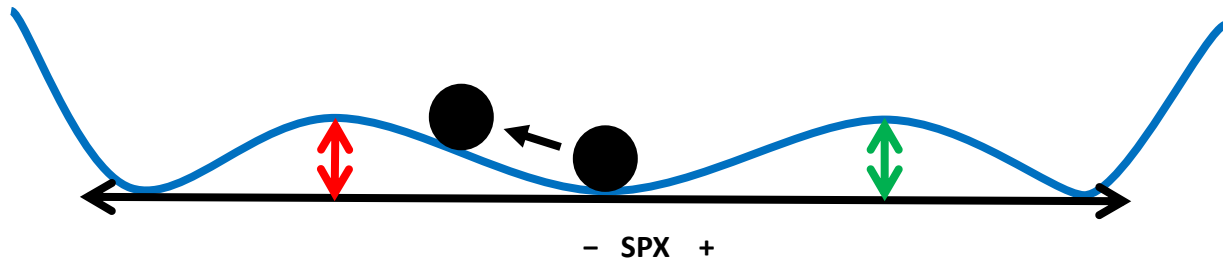
PM: Hey, false alarm, let's start putting XYZ back on. I really like that stock.

This is reflexivity. It's a bitch.

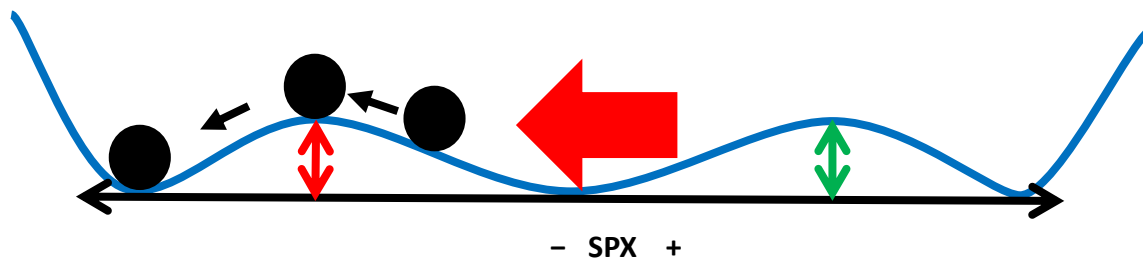
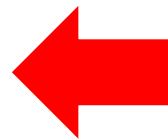
Like Copernicus, though, Soros has some problems with the concept of reflexivity as expressed in *Alchemy of Finance*. As written (and for all I know, Soros has kept his best work secret in order to build a fortune), reflexivity is more of a heuristic – a rule of thumb or a way of looking at data – than a practical methodology that can be incorporated into a rigorous evaluation. **There's no language to reflexivity other than the language of price, and that's a problem for Soros in the same way that it's a problem for technical analysis ... it limits the enterprise in both scope and accuracy.** But in the same way that elliptical planetary orbits provided the key for translating the central insights of the original Copernican theory into an extremely powerful (i.e., useful) heliocentric model of the solar system, I believe that information theory can translate the central insights of reflexivity into an extremely powerful (i.e., useful) behavioral model of markets.

Here's the basic idea of how to describe reflexivity in informational terms. Let's say you have an unstable equilibrium, meaning that the informational barriers for the current price equilibrium to start

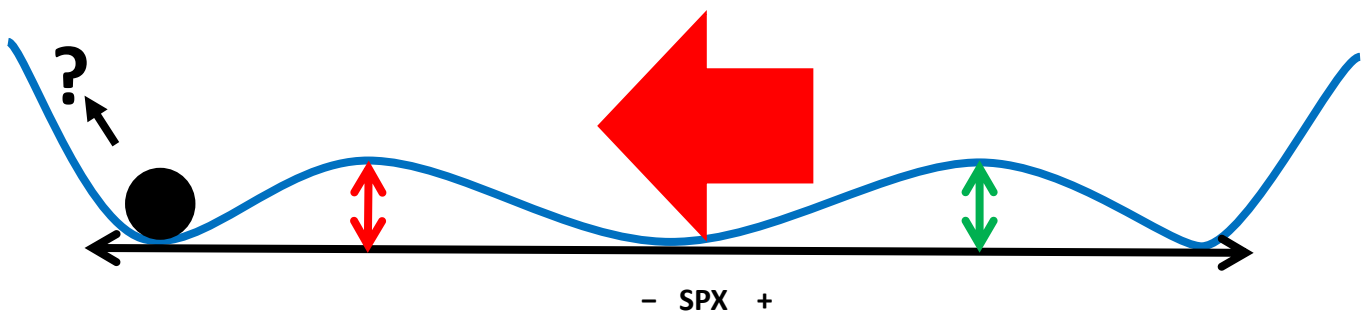
moving in one direction or the other are quite low. For whatever reason, maybe just the chance result of a large number of Sell orders clustering in time, the equilibrium starts to “roll” to the left.



That price action in and of itself creates a new informational signal.



And if that signal is large enough to push the price outcome to a new equilibrium, then another, perhaps larger signal is generated simply by the price action.



And so on and so on. In retrospect it always seems obvious that the market just “had a mind of its own” and that there was nothing “real” to make the price go down. But when you’re in the middle of one of these episodes it’s not obvious at all. We are biologically hard-wired to pay attention to these signals and to interpret them as part of a larger, more meaningful pattern. These price action signals are entirely real as we experience them, and I think it’s critical to have an investing perspective that treats them as entirely real. That’s what Information Theory provides. **By looking at the phenomenon of reflexivity through the lens of Information Theory, we can “see” its dynamics more clearly than if we’re just looking at price, and as a result we have the potential to anticipate and/or react more appropriately when these events occur.**

This, then, is the goal of Epsilon Theory – to develop a practical methodology to identify the securities prone to game-playing behaviors like reflexivity, and the conditions under which game-playing behavior is more or less likely to occur. By building on the insights of brilliant thinkers like George Soros, E.O. Wilson, and Brian Skyrms I think it’s a very achievable goal. Whether that ultimately sparks a new investment paradigm ... who knows? But I’m pretty sure it can help us catch more mice.