Epsilon Theory

Viewing Capital Markets through the Lenses of Game Theory and History

By W. Ben Hunt, Ph.D.

Our times require an investment and risk management perspective that is fluent in econometrics but is equally grounded in game theory, history, and behavioral analysis. Epsilon Theory is my attempt to lay the foundation for such a perspective.

The name comes from the fundamental regression equation of modern portfolio management:

$$y = \alpha + \beta + \varepsilon$$

where the return of a security (y) is equal to its idiosyncratic factors (alpha) plus its co-movement with relevant market indices (beta) plus everything else (epsilon).

The language of professional investment is dominated by this simple econometric formulation, and the most fundamental questions regarding active portfolio management – does an investment strategy work? how does an investment strategy work? – are now entirely framed in terms of alpha and beta, even if these words are not used explicitly. When investors ask a portfolio manager "what's your edge?" they are asking about the set of alpha factors that can differentiate the performance of an actively managed portfolio from a passively managed portfolio. Even a response as non-systematic as "I know everything about the semiconductor industry and I have a keen sense of when these stocks are over-valued or under-valued" is really a statement about alpha factors. It is a claim that there is a historical pattern to security price movements in the semiconductor industry, that these movements are linked to certain characteristics of semiconductor companies, and that the manager can predict the future state of security prices in this industry better than by chance alone by recognizing and extrapolating this historical pattern.

This notion – that observed characteristics of securities, companies, or the world determine to a large extent the future prices of securities – is so ingrained in the active investment management consciousness that it is hard to imagine an alternative. If the observed characteristics of a security or its underlying economic entity or its relevant events are not responsible for making the price of the security go up or down, then what is? If market co-movement (beta) is the answer, then the passive investment crowd is right and we should just put our equity allocations into broad market ETF's and call it a day.

Unfortunately for the active management community, alpha factors have not done terribly well in recent years, regardless of asset class, investment strategy, geography, etc. I'm not saying that active managers as a group have not had positive performance. I'm saying that on both a risk-adjusted and a non-risk-adjusted basis the population of active managers today has underperformed prior populations of active managers to a significant degree. Are there individual exceptions to this general observation? Of course. I am making an observation about a population, not any individual member of the population. But I don't think it's a particularly contentious statement to say that the enterprise of active investment management has been challenged over the past five years.

One way to improve the efficacy of active management is to do better with alpha identification … to identify new historical patterns (including the pattern of pattern change), to measure the characteristics of securities and companies and events more accurately, etc. It seems to me, though, that this sort of effort, where we seek to add one more term to the list of alpha variables or improve the list we already have, is inevitably an exercise in diminishing returns, and a crowded exercise at that. I think it is ultimately a dead end, particularly in an era of Big Data technology and strong regulatory proscriptions against private information regarding public companies.

Instead, I think we should be looking *outside* the confines of factor-based investment analysis. We can't squeeze much more juice out of the alpha fruit, and we know that beta gives no sustenance to the active investor. But what about epsilon? What about $\boldsymbol{\varepsilon}$? We pejoratively call this an "error" term, and the goal in any applied econometric exercise is to make this term as small and inconsequential as possible. That makes perfect sense if we are trying to predict the future states of, say, decaying nuclear particles, where it seems unlikely that there is any agency or causal process outside of the particles themselves (i.e., outside the physical universe). But it makes no sense at all if we are investigating a *social* phenomenon such as a financial market, where strategic human behavior and decision making play a crucial role, but a role largely exogenous to the observed characteristics of the financial universe.

It's the epsilon term that I want to explore, because it includes anything that cannot be expressed easily in econometric terms – things like strategic decision-making and shifting behavioral preferences. Modern portfolio theory ignores these dynamic behavioral characteristics by assumption, as the epsilon term is defined as residual and random information from the perspective of the static factors defined within the alpha and beta terms. Because decision-making and behavioral characteristics cannot easily be expressed in the language of factors and regression, they are essentially invisible to the econometric eye.

Roy Lichtenstein, "I Can See The Whole Room …" (1961)

Fortunately, there is both a language and a lens available to analyze these human behavioral patterns in a rigorous fashion: game theory. Game theory and its close cousin, information theory, allow us to extract non-random, non-residual information from the epsilon term, which in turn allows us to predict or understand the likely return of a security more accurately.

A quick example of what I mean: on Friday, November 9th Obama gave his first post-election speech on the Fiscal Cliff. The market reacted negatively to his calls for an immediate House vote on middle-class Bush tax cut extensions and for the public to pressure House Republicans to accede.

Bloomberg: S&P 500 November 9th, 2012

On Wednesday, November 28th Obama gave almost *exactly* the same speech, down to the same phrasing of specific arguments and the staging of the event. The market, however, reacted very positively to this speech.

Bloomberg: S&P 500 November 28th, 2012

The speeches themselves are events, which are fair game for econometric analysis, and I imagine there are event-driven investment strategies that include content analysis of speeches like this as an alpha factor. Unfortunately for those strategies, however, we see markedly different future states of the equity markets given almost identical factor inputs. Whatever probability assessment one made of the likely S&P 500 close after an Obama speech with characteristics X after observing November 9th was almost certainly dead wrong on November 28th because the characteristics were identical. There is something *outside* of an econometric event-driven model going on here, and determining whether some future Obama speech is going to push the market up or down almost certainly depends on identifying that exogenous "something" far more than parsing the Obama speech more carefully.

I think that the exogenous "something" is the informational or decision-making structure of the market as revealed by game theory. My belief is that the difference between the two events lies in the structure of the underlying Common Knowledge game (what everyone thought that everyone thought about the Fiscal Cliff on November 9th versus what everyone thought that everyone thought about the Fiscal Cliff on November 28th), and in how the game was mediated and narrated by Bloomberg, CNBC, and the Wall Street Journal. Good luck capturing that dynamic in a regression analysis!

Or to take a more recent example, consider the recent plunge in the price of gold. Here's how Alen Mattich "explained" the sharp drop in the MoneyBeat column of the Wall Street Journal on May 20th:

> But just as there wasn't any real logic needed to keep prices advancing when everyone was caught up in the euphoria, there's no need for logic to intrude in the fall either. These things take on a life of their own. Especially when there's so little rational basis on which to price these assets in the first place.

If you're looking solely through the lens of factor analysis, Mattich is right: what's happened recently in gold prices makes no sense. *But through the lens of game theory, there is absolutely a logic and a rational basis for this market behavior.* Game theory is explicitly designed to help explain events that otherwise appear to have "taken on a life of their own", and my goal in Epsilon Theory is to elucidate and communicate that explanatory perspective to as broad an audience as possible.

I believe that we are witnessing a structural change in markets, brought on by a witches' brew of global debt crisis, new technology, and new regulatory regimes. By structural change I mean a fundamental shift in the market's relationship to society and politics, as well as a sea change in the behavioral preferences of market participants. Modern portfolio theory takes both of these terms – market rules and market participant preferences – as constants, and as a result it is impossible to see the impact of structural change by looking solely through the lens of alpha and beta factor analysis. We need another lens.

Here's an easy example of what I mean … in modern portfolio theory Risk-On/Risk-Off does not exit. We all know that it's out there, and we can even see some its impact on measurable alpha and beta factors, sort of a Risk-On/Risk-Off effect by proxy. But there is nothing in any alpha or beta factor that explains or predicts Risk-On/Risk-Off. It's like trying to see Dark Matter with a telescope. We know that Dark Matter is out there in the universe, but a telescope detects photons, which is pretty good for most astronomical tasks, but not if you're trying to see something that doesn't interact at all with light. Why can't factor analysis "see" Risk-On/Risk-Off? Because Risk-On/Risk-Off is neither an attribute of a security nor a discrete event; it is a *behavior* that *emerges* from a strategic decision-making structure, and factor analysis simply cannot detect behaviors.

My intent is not to rain on the econometric parade. My intent is to show its limitations and suggest an additional methodology for improving the efficacy of active investment management. From an econometric perspective, strategic human behavior and decision-making may reside in epsilon, the "error

term", where it is, by definition, largely impervious to econometric tools.[1] But that does not mean that these strategic human behaviors are unpredictable or unknowable. It simply means that we need an entirely different tool kit, and that's what game theory is.

Game theory is only useful for social phenomena. It is a methodology for understanding strategic decision making within informational constraints. I say "strategic" because, like the tango, it takes (at least) two decision makers to play a game, and each player's decisions are made in the context of expectations regarding the other player's decision-making process. Game theory does not see the world in terms of factors and historical correlations. It sees the world in terms of equilibria, as decision-making balance points where strategically-aware players have no incentive to make alternative decisions. Movement from one equilibrium to another is determined entirely by changes in the perceived pay-offs of the possible decisions, which is another way of saying that behavioral change is determined entirely by a change in the information available to the players regarding future probabilities of future states of the world.

The game of poker provides an instructive corollary for evaluating the relative strengths of game theoretic and econometric analysis. Econometric or factor analysis is the equivalent of "playing the cards", where decisions are based on the odds of this card or that card appearing relative to the revealed strengths of other players' hands and the potential stakes to be won or lost. Game theoretic analysis, on the other hand, is the equivalent of "playing the player", where decisions are based on a strategic assessment of the likely behavior of other players relative to the informational signals provided by bets. If you want a tool kit to evaluate the static factors that *describe* the structure of a poker game or a capital market, then econometrics is the right choice. Game theory, on the other hand, is the right choice if you want to evaluate the dynamic interactions that *emerge* from the structure of a poker game or a capital market.

Cassius Coolidge, "A Friend In Need" (ca. 1908)

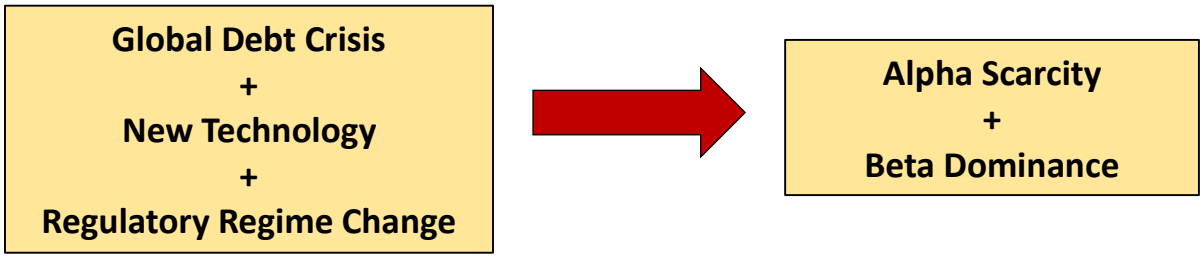
[1] I'm sure that there are econometricians who can construct elaborate models to represent game theoretic behaviors and outcomes. But aside from some goal of methodological purity or unity … why? Again, I'm not trying to pick a fight. I'm just trying to use the right tool for the job.

The need for this combined perspective has never been greater. As Mohamed El-Erian writes with his customary clarity:[2]

> The recent volatility [in gold] speaks to a dynamic that has played out elsewhere and, more importantly, underpins the gradually widening phenomenon of western market-based systems that have been operating with artificial pricing for an unusually prolonged period.
>
> … think of the underlying dynamic as one of a powerful brand where valuation has become completely divorced from the intrinsic attributes of the product – thus rendering it vulnerable to any change in conventional wisdom (or what economists would characterize as a stable disequilibrium).
>
> … Essentially, today's global economy is in the midst of its own stable disequilibrium; and markets have outpaced fundamentals on the expectation that western central banks, together with a more functional political system, will deliver higher growth.

What El-Erian calls "change in conventional wisdom" is *exactly* the phenomenon that game theory perceives well. Conversely, it is exactly the phenomenon that factor analysis perceives poorly.

My only quibble with El-Erian is that the disjuncture between security prices of all sorts and fundamentals is not only a function of central bank policy designed specifically to create that disjuncture, but is also a function of new technology and regulatory regime shifts. Simply reversing the extraordinary measures taken by the Fed and its acolytes won't put the Big Data genie back in the bottle, or reverse the impact of Reg FD and Reg NFM. I'll have a lot more to say about the structural impact of technology and regulatory policy change in future letters, but here's the bottom line: all of these changes create significant challenges for active investment management. The new policy regimes make it much more difficult for any investment firm to acquire private information about a public company legally, and the new technology ensures that any investment advantage gleaned from public information will be arbitraged away almost immediately. The result is *alpha scarcity and beta dominance*, a poisonous environment for

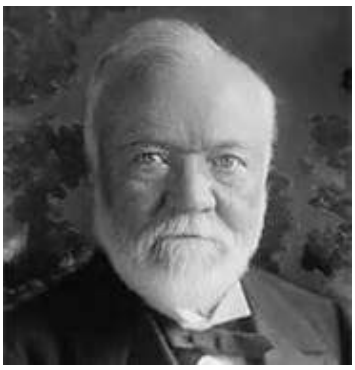


[2] *Financial Times*, "Markets Insight: We should listen to what gold is really telling us," May 20, 2013.

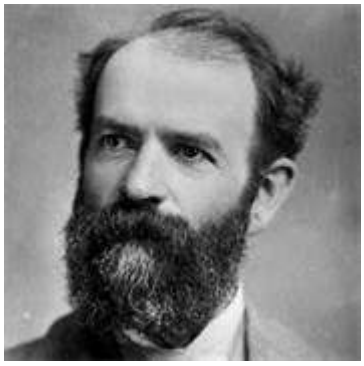
active investment managers of all stripes, as well as the Wall Street firms with business models designed to support active investment management. Welcome to the New Normal.

But here's the thing … *this has all happened before*. The New Normal turns out to be an Old Normal, or at least an Intermittent Normal, and history provides a crucial lesson for active investors seeking to ride out the current storm. Risk-On/Risk-Off behavior is nothing new, you just have to look back before World War II. Risk-On/Risk-Off was an accepted fact of market life in the U.S. for 100 years, from at least the 1850's all the way through the 1940's, because the conditions that create a structure where Risk-On/Risk-Off behavior emerges – global financial crisis + new technology + regulatory regime change – were so commonplace. We think that the Internet has changed the way we make investment decisions … imagine what the telegraph and the telephone did. We worry about central bank decisions to expand their balance sheets … imagine the concern over the creation of fiat currency and the outlawing of gold ownership. The New York Stock Exchange survived a Civil War and two World Wars quite nicely, thank you, and there were actual human investors who thrived during these decades, all without the benefit of Modern Portfolio Theory. It might behoove us to learn a thing or two from these men.

Here's the big lesson I've gleaned from reading first-hand accounts of pre-World War II investors – *they were all game players*. Understanding, evaluating, and anticipating the investment decisions of other investors was at least as important to investment success as understanding, evaluating, and anticipating the future cash flows of corporations. To men like Andrew Carnegie, Jay Gould, and Cornelius Vanderbilt – just to name three of the more famous investors of this time – the notion that they would make any investment without strategically considering the decision-making process of other investors would be laughable. In fact, most of their public investments were *driven* by the strategic calculus of "corners", "bulges", and "points". These men played the player, not the cards, in almost everything they did.



Andrew Carnegie



Jay Gould

Cornelius Vanderbilt

To take one of literally hundreds of examples, it wasn't some great secret that Jay Gould and James Fisk were trying to corner the gold market in the summer of 1869. They were buying in the open market and clearly communicating their intentions to every market participant, big and small. What they didn't communicate was that they had a mole in the Grant Administration, someone who would tip them off to any government gold sale. Some investors figured out Gould's game and avoided the original Black Friday, September 24th 1869, when the Grant Administration sold $4 million worth of gold in the open market and crushed the corner. Other investors (including some in Gould's inner circle) were themselves crushed. The point is that everyone involved in the capital markets in 1869 was trying to figure out the behavioral intentions of a few very public figures, and investment success or failure in any security depended mightily on this strategic assessment. There was no hand-wringing and moaning about the "divergence of prices from their fundamentals". It was just an accepted fact of life that yes, fundamentals mattered, but game-playing mattered a lot, too, and often it was the only thing that really mattered.

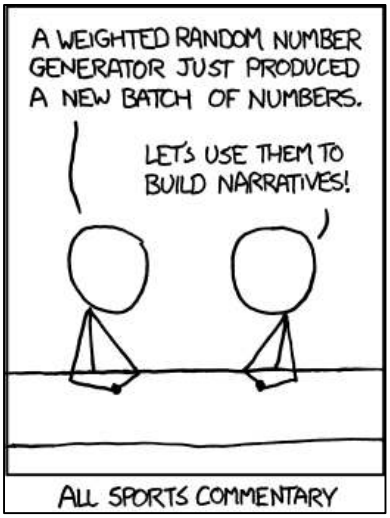
Are the subjects of game-playing in markets different in 2013 than they were in 1913? Sure. The days of "corners" are largely over, or at least illegal, just as the days of cozying up to management for non-public fundamental information are now largely over, or at least illegal. But the nature of game-playing hasn't changed, and the centrality of game-playing to successful investment, particularly during periods of global economic stress, hasn't changed at all.

The secret of effective market game-playing, whether you were an investor 100 years ago or you are an investor today, is to recognize that the market game hinges on the **Narrative**, on the strength of the public statements that create **Common Knowledge**. These are the core concepts of Epsilon Theory.

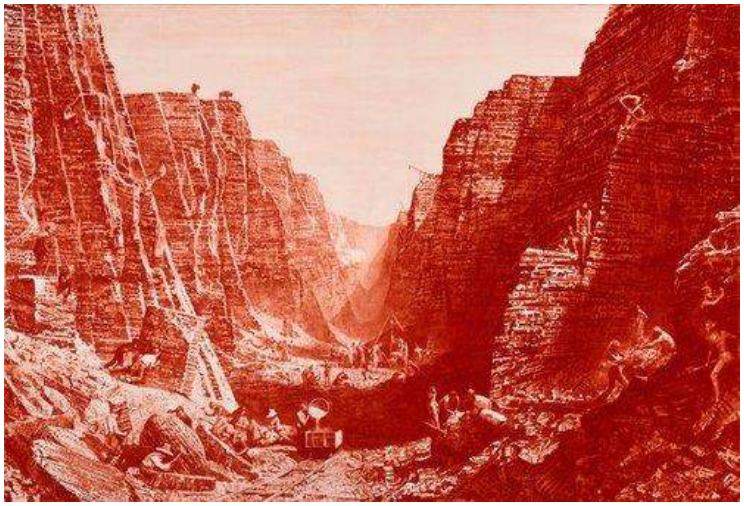
Rene Magritte, "The Treachery of Images" (1929)

The concept of Narrative is a thoroughly post-modern idea. What I mean by this is that Narrative is a social construction, a malleable public representation of malleable public statements that lacks any inherent Truth with a capital T. In fact, the public statements that go into the construction of a Narrative are often intentionally untrue.

As Jean Claude Juncker (far left in photo), Luxembourg PM and former Eurogroup Council President, famously said in reference to market communications, "When it becomes serious, you have to lie." And even if the information behind a Narrative is not intentionally a lie, it may have zero causal or correlative relationship to the Narrative. Nate Silver captured this idea well in a cartoon on the statistical analysis (or lack thereof) underlying the business of sports commentary, and precisely the same critique can be made of the business of financial market commentary. The financial news media has to say *something*, and they have to be saying something *all the time*. So they will. There's nothing evil or immoral about this. It is what it is. But it's critical to recognize a Narrative for what it is and not imbue it with superfluous attributes, such as Truth. To be effective, it is only important for a Narrative to *sound* truthful (this is what Stephen Colbert calls "truthiness", which is actually a very interesting concept, not to mention a great word), not that it *be* truthful. A Narrative may in fact be quite truthful, but this is an accident, neither a necessary nor a sufficient condition of its existence.



My goal with Epsilon Theory is not to somehow expose a Narrative for being demonstrably untrue or disconnected from facts (although sometimes I just can't help myself). And while it can be personally satisfying to indulge one's righteous indignation by asking *cui bono* – who benefits? – from some particularly egregious representation of the world, that, too, is really here nor there. Demanding some arbitrary degree of truthfulness from a



Mark Tansey, "Constructing the Grand Canyon" (1990)

Narrative is a categorization error, pure and simple, and something of a conceit, to boot. No, I want to use a proper conception of Narrative, which has no inherent notion of truthfulness and is simply a public representation of a set of public statements made by influential people about the world, because I think that this can help me predict market behaviors that are not easily predictable by factor-based or econometric analysis. To that end, my goal with Epsilon Theory is to identify Narratives, measure their strength, and assess their likely impact on security prices through an application of game theory and information theory.

Human history is littered with the corpses of dead Narratives, from the ancient myths of Greece or Rome to more modern concepts such as Manifest Destiny or Cultural Revolution. By definition, the verdict of history (which itself is a socially constructed representation of actual historical facts) has not been kind to dead Narratives, in that we see them now as myths, which is to say, as Narratives whose constituent public statements have lost whatever power they once had to move us.

John Gast, "American Progress" (ca. 1872)

Mao Zedong Thought poster (ca. 1970)

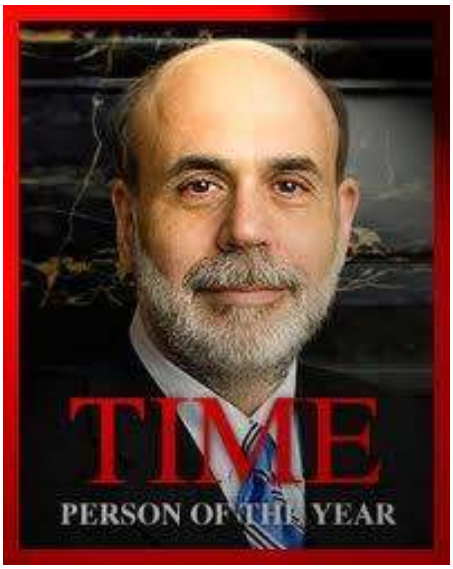
It's all too easy either to chuckle or raise a disapproving eyebrow at these more modern myths, wondering how anyone could be swayed or motivated by what seems to be obvious propaganda, which is to say, public media messages that no longer create Common Knowledge. But back in their respective days, these Narratives were powerful, indeed.

Many older Narratives have kept their potency. For example, the Narrative of the American Founding Fathers is just as powerful today as it was 100 years ago, maybe more so. There is no inherent expiration date on a Narrative, and it can survive as a driver of behavior so long as it regenerates itself by sparking influential public statements that create widespread Common Knowledge. This is certainly the case with the ongoing representations of public statements made by Washington, Madison, Jefferson, etc. over 200

years ago. Not only are their public statements still retransmitted and remediated in a positive light, but they are widely referenced by current influential speakers with new public statements on a daily basis.

It's the new Narratives, though, that I am most interested in. How do they emerge? How do they sustain themselves? How do they manifest themselves in predictable patterns of behavior?

For example, the current Narrative associated with Federal Reserve policy is just as powerful and just as real as any historical Narrative I am aware of, including the Narratives of global religions and major nationalities. Fifty years from now, will we look back on Central Bank Omnipotence as a dead myth, as something akin to Manifest Destiny, or will it continue to shape our expectations and behaviors as the Founding Fathers Narrative does? The answer to this question will almost certainly *not* depend on the actual efficacy of Federal Reserve policy! Narratives tend to die with a whimper, not a bang, and even successful Narratives from a policy perspective (as Manifest Destiny surely was) can wither as they are supplanted by new interpretations and representations of the world that better serve the interests of the economic and political entities that promulgate Narratives.



***Time*, December 16, 2009**

***il Giornale*, August 3, 2012**

For a current Battle Royale between two competing Narratives, look no further than Europe. On the one hand, we have the Narrative of European Union, which is a potent and vibrant public representation of an active set of public statements by extremely influential people advocating shared notions of identity and sovereignty across national European borders. This Narrative serves the interests of a large mandarin class of bureaucrats, as well as the economic interests of most European companies. And on the other hand, we have the Narrative of German Hegemonic Desires, advocating political resistance to Germany's imposition of its preferred economic

policies through EU mechanisms. This Narrative serves the interests of Opposition political parties and is particularly strong in Italy under the aegis of Berlusconi's media empire. Neither of these competing European Narratives is going away anytime soon, if ever. But the waxing and waning of one versus the other has investable consequences for market behaviors, and it is this assessment of the Narrative battlefield, if you will, where the Epsilon Theory perspective can provide direct benefits.

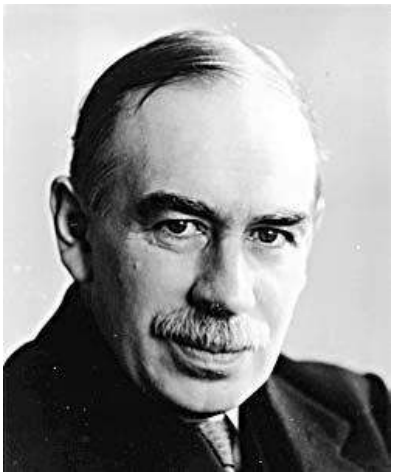
The link between Narrative and behavior is Common Knowledge, which is defined as what everyone knows that everyone knows. This is actually a trickier concept than it might appear at first blush, because as investors we are very accustomed to evaluating the consensus (what everyone knows), and it's easy to fall into the trap of conflating the two concepts, or believing that Common Knowledge is somehow related to your private evaluation of the consensus. It's not. Your opinion of whether the consensus view is right or wrong has absolutely nothing to do with Common Knowledge, and the consensus view, no matter how accurately measured or widely surveyed, is never the same thing as Common Knowledge.

Common Knowledge is, in effect, a second-order consensus (the consensus view of the consensus view), and it is extremely difficult to measure by traditional means. You might think that if a survey measures a consensus, then all we need to do is have a survey about the survey to measure a consensus view of the consensus view and hence Common Knowledge, but you would be wrong. What would the second survey ask? Whether or not the second-survey individuals agree with the first-survey individuals? Common Knowledge has nothing to do with whether the second-survey individuals think the original consensus view is right or wrong … that would just be an adjustment of the original survey. What you're trying to figure out is the degree to which everyone believes that everyone else is relying on the original survey as an accurate view of the world, which has nothing to do with whether the original survey does in fact have an accurate view of the world. It has everything to do, however, with how widely promulgated that original survey was. It has everything to do with how many influential people – famous investors, famous journalists, politicians, etc. – made a public statement in support of the original survey. It has everything to do with the strength and scope of the Narrative around that original survey, and this is what you need to evaluate in order to infer the level of Common Knowledge in play regarding the original survey.

Now obviously it's unlikely for a powerful Narrative like Central Bank Omnipotence to emerge around a survey, but replace the words "original survey" with "consensus view that the Fed has got your back" and you'll see how this works.

The more Common Knowledge in play at any given time, the more that market behaviors will be driven by the rules and logic of the Common Knowledge Game than by fundamentals or traditional factors. I've written extensively about the CK Game in my prior letters, so I won't repeat all of that here (for a collection of this work see http://epsilontheory.com/doc-archive/). Suffice it to say that you'll be reading a lot more about specific applications of the CK Game in future letters. You'll also be reading a lot more about pre-World War II investing in future letters, as I find that matching examples of successful game-playing in the past with opportunities for game-playing today is a very effective way of communicating the power and relevance of Epsilon Theory.

On that note, I want to conclude with an extended passage from John Maynard Keynes, writing in the 1930's about the game-playing he saw and experienced on a daily basis with his personal investing.



"Thus the professional investor is forced to concern himself with the anticipation of impending changes, in the news or in the atmosphere, of the kind by which experience shows that the mass psychology of the market is most influenced.

This battle of wits to anticipate the basis of conventional valuation a few months hence, rather than the prospective yield of an investment over a long term of years, does not even require gulls amongst the public to feed the maws of the professional; it can be played by professionals amongst themselves.

Nor is it necessary that anyone should keep his simple faith in the conventional basis of valuation having any genuine long-term validity. For it is, so to speak of, a game of Snap, of Old Maid, of Musical Chairs – a pastime in which he is victor who says *Snap* neither too soon nor too late, who passes the Old Maid to his neighbour before the game is over, who secures a chair for himself when the music stops. " …

"Or, to change the metaphor slightly, professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preference of the competitors as a whole; so that each competitor has to pick, not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point view. It is not a case of choosing

those which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest.

We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practise the fourth, fifth and higher degrees." – ***The General Theory of Employment, Interest, and Money*** (1935)

Any investment manager who has watched market indices tick-by-tick after an FOMC announcement knows the truth of what Keynes wrote 80 years ago. It clearly doesn't matter what you think about the Fed statement itself. And you quickly learn that it doesn't matter what you think about whether expectations of the Fed statement were met or not, because as often as not the market will go in the opposite direction that you surmised.

What you want to know is what everyone thinks that everyone thinks about the Fed statement, and you can't find that in the Fed statement, nor in any private information or belief. You can only find it in the Narrative that emerges after the Fed statement is released. So you wait for the talking heads and famous economists and famous investors to tell you how to interpret the Fed statement, but not because you can't do the interpreting yourself and not because you think the talking heads are smarter than you are. You wait because you know that everyone else is also waiting. You are playing a game, in the formal sense of the word. You wait because *it is the act of making public statements that creates Common Knowledge*, and until those public statements are made you don't know what move to make in the game.

As Keynes wrote, you are devoting your intelligence to anticipating what average opinion expects the average opinion to be. And there is nothing – absolutely nothing – in the standard model of modern portfolio theory or the fundamentals of the market or any alpha or beta factor that can help you with this effort. It's not that the standard model is wrong. It's just incomplete, both on its own terms and, more importantly, in that it was never intended to answer questions of strategic behavior. You need an additional tool kit, one designed from the outset to answer these questions. That's what Epsilon Theory is intended to be, and I hope you will join me in its development.

Ben Hunt

http://EpsilonTheory.com

