

Schrödinger's Portfolio

The world is given to me only once, not one existing and one perceived.

– *Erwin Schrödinger*

Quantum theory provides us with a striking illustration of the fact that we can fully understand a connection though we can only speak of it in images and parables.

– *Werner Heisenberg*

What we observe is not nature itself, but nature exposed to our method of questioning.

– *Werner Heisenberg*

I have approximate answers and possible beliefs and different degrees of uncertainty about different things, but I am not absolutely sure of anything and there are many things I don't know anything about. ... I don't feel frightened not knowing things, by being lost in a mysterious universe without any purpose, which is the way it really is as far as I can tell.

– *Richard P. Feynman*

Chance is commonly viewed as a self-correcting process in which a deviation in one direction induces a deviation in the opposite direction to restore the equilibrium. In fact, deviations are not "corrected" as a chance process unfolds, they are merely diluted.

– *Amos Tversky and Daniel Kahneman*

There's no one thing that's true. It's all true.

– *Ernest Hemingway, "For Whom the Bell Tolls"*

Want a cookie?

– *Teddy KGB ("Rounders", by David Levien and Brian Koppelman)*

“Schrödinger’s Cat” is a famous thought experiment proposed in a series of letters between Erwin Schrödinger and Albert Einstein in 1935 as they discussed the mysteries and implications of quantum physics. As Schrödinger posed the question, imagine a cat within a closed box that also contains a small source of radioactivity, some sort of Geiger counter to detect any radiation emission, and a hammer poised to break a flask of deadly poisonous gas if the Geiger counter is triggered. The behavior of each atom within the radioactive source is ruled by quantum mechanics, where – according to the mainstream theory – both a non-decayed state of each atom (no radiation emission) and a decayed state of each atom (radiation emission) exist simultaneously in a sort of probabilistic overlap until some outside observer measures the system and “collapses” the probabilities of the two overlapping atom states into either the single decayed or the single non-decayed state. But until that outside observer opens the box, the radiation-emitting state of the atom exists at the same time and in just as real a fashion as the non-radiation-emitting state of the same atom.

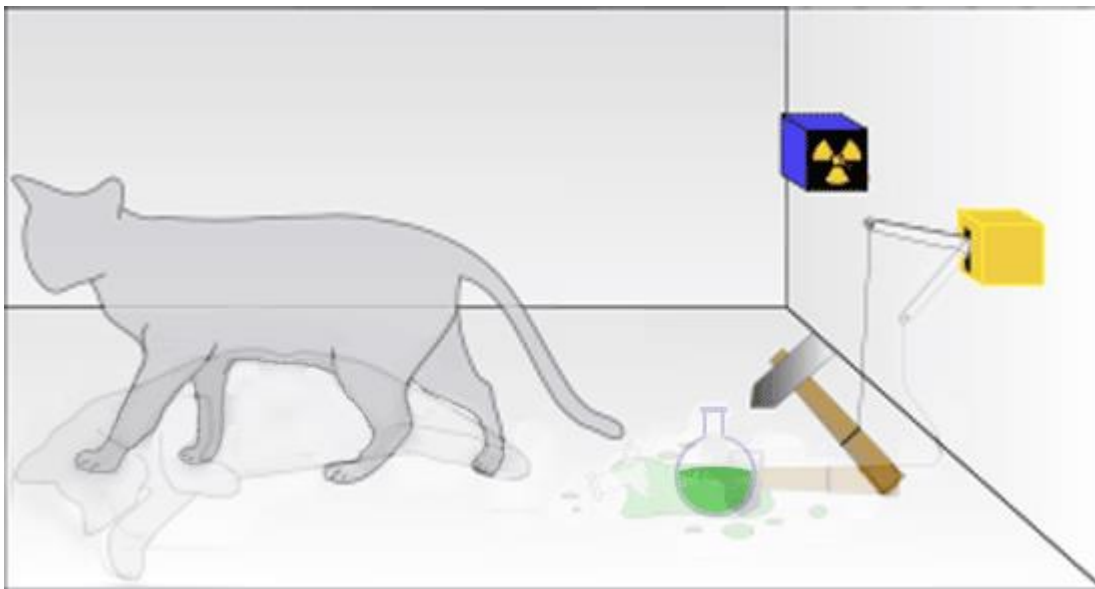


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It’s all well and good, Schrödinger wrote, to imagine this sort of weird probabilistic overlap of two mutually exclusive states existing simultaneously in the world of sub-atomic physics, but what about our world? Since the deadly poison will be released only if the radioactive particle is detected, and the particle is governed by these probabilistic rules of simultaneous existence, is the same true of the poison’s release and the cat’s life? Is the cat both simultaneously alive and dead in a probabilistic state of super-positioning until an observer opens the box and measures what really transpired?



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The meaning and purpose of Schrödinger's thought experiment is often misunderstood. He was NOT trying to say that the act of opening the box and measuring the system would either save or kill the cat. This would be an *observer effect*, similar to what happens when you measure the air pressure in a tire or you agree to a credit check. A little bit of air comes out of the tire in the application of the air pressure gauge, just as many credit evaluation algorithms reduce your score ever so slightly every time someone looks at your credit score. The observer effect is a huge problem in the investment world, as the act of observing investment performance on this time period versus that time period or against this index versus that index has an enormous and entirely inefficient impact on manager behavior, and I'll have a lot more to say about this in future notes. But that's not the point of Schrödinger's Cat and it's not the point of this note.

What Schrödinger was saying is something much more subtle and much more important. **We do not live probabilistic lives. We are not probabilistic entities. How, then, do we make sense of a world composed of probabilistic entities and controlled by probabilistic forces?** Our task would be easier if we could experience the world directly as a set of probabilities or "see" the simultaneity of these overlapping probabilistic states, and that is exactly the advantage that machine intelligences have over human intelligences (see "[Rise of the Machines](#)"). But this is not a perceptual or experiential capacity that humans can learn or develop, any more than we could learn to see through an insect's compound eye. For better *and* worse, our decision-making is the product of millions of years of biological evolution and hundreds of thousands of years of social training. Our actual human lives are spent in a social environment where our cats are either alive or dead and where our investments are either up or down,

even if the universe is more fully understood in some other manner. We have to play the cybernetic cards we've been dealt, which means that, as Schrödinger wrote, "The world is given to me only once, not one existing and one perceived."

Werner Heisenberg's Uncertainty Principle – which says that it is impossible to know the position and momentum of a quantum entity simultaneously – presents exactly the same common misinterpretation and the same profound question as Schrödinger's Cat. What the Uncertainty Principle expresses is not the inevitability of an observer effect, where measuring a particle's position changes its momentum and vice versa, but rather that the building blocks of our universe can only be understood as probabilistic entities, as "blurry smears" of information against some mathematical likelihood function. We cannot be completely certain of the simultaneous properties of position and momentum for an atomic particle no matter how light the touch or perfect the calibration of our measuring instruments. Uncertainty is a fundamental property of our world, and the best we can achieve under any circumstances is an incomplete and probabilistic knowledge of that world.



The extent or proportion of that fundamental property of uncertainty varies from system to system, and any system in the universe – from sub-atomic particle interactions to the gravitational pull of galaxy clusters to anything in between – can be seen as a combination of *deterministic processes* (events that are governed by the rules of causality and certainty) and *stochastic processes* (events that are governed by the rules of probability and chance). Nothing is purely deterministic or certain in this universe, but by the same token, so long as one non-decayed atom exists nothing is purely stochastic or random, either.

Most natural systems that occur at the level of human evolutionary experience on the African savannah tend to be much more dominated by deterministic processes than stochastic processes. For example, from a human perspective there is a perfectly deterministic and causal relationship that describes an apple falling from a tree, and as a result Isaac Newton's theory of gravity has no incorporation of stochastic rules. It's only when Einstein and others start explaining the nature of gravity in environments

that are totally foreign to all of human existence – sub-atomic interactions or black holes and the like – that the rules of probability and chance take on a meaningful and at times dominant role.



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Unfortunately, this means that humans are, by nature, really bad at identifying and coping with stochastic processes that do, in fact, play a meaningful role in our lives. Machiavelli wrote of “the bitch Goddess Fortuna” as the great adversary of successful human societies, and even a casual reading of history suggests he’s not wrong. More unfortunately for anyone reading this note, the single most pronounced instantiation of a human-level system that is not just impacted but is dominated by stochastic processes is the modern market.

It’s not only that investors are terrible at identifying the size and frequency of rare tail probability events, of Black Swans to use Nassim Taleb’s memorable phrase. The far larger problem is that investors neither recognize nor cope well with the degree to which day-to-day market activities are dominated by the rules of chance and randomness. Every investment decision we make is a decision under great uncertainty, where the objects of our decision-making – securities and their future prices – are really only understandable as probabilistic blurs. Is there a deterministic component to markets? Absolutely. But the concepts of *risk and reward* are dominated by the logic of chance and randomness, not the logic of causality. If you want a metaphor for a quantum mechanics perspective on the modern market, imagine all of us active investors and allocators standing on a narrow beach of the reality that makes sense to us, while a vast, seething ocean of indeterminate risk/reward probability states stretches far off to the horizon. **How we cope with that probabilistic ocean and our imperfect human view of the world-as-it-is is crucially important for investment success, but it is the rare investor who swims confidently in a sea of risk.** It takes a unique human intelligence like Richard Feynman’s to be comfortable “being lost in a mysterious universe without any purpose”, which is a superb description of how humans experience the stochastic world. It’s really hard to grasp how the stochastic forces of

chance “dilute” the reality of our daily lives, to use Amos Tversky and Daniel Kahneman’s phrase. Little wonder that we mere mortals tend to stay out of the water as much as possible.

Every active investor I have ever known, and that certainly includes me, responds to the pervasive uncertainty of markets by trying to make them less uncertain. We do not embrace the probabilistic nature of future security prices; we fight it. Looking for a way to stack the odds of a future transaction in one’s favor goes back at least as far as Jacob and Esau, and like Jacob we are all looking for an “edge”. We are all looking for some pattern or signal or piece of information that makes our estimation of the future more certain than it was before we acquired that information. **Whether we are top-down macro investors or bottom-up fundamental investors, quantitative specialists or industry experts, bond guys or stock guys, long-term holders or short-term traders ... we are all looking for a tell.**



In poker, a tell is some unintended tip or signal by a player that gives useful information about the cards he holds. In *Rounders*, the best movie about decision-making under uncertainty that I am aware of, the villainous Teddy KGB is finally laid low by Mike’s recognition of a tell – when Teddy has a sure winner of a hand he breaks open his Oreo cookies and eats them; when Teddy is bluffing he breaks them open but doesn’t eat them.

As active investors we are all looking for Nature’s tell in whatever way fits our abilities and the way we see the world. I know guys who spend hours a day, every day, calling management, IR, analysts ... anyone they can get on the phone ... looking for that tell. Others spend their days poring through 10-q’s and financial statements. Others are in a never-ending search for a wise man to reveal the tell. Others find their tell in some macro data series. Others believe that constructing the world’s most detailed DCF model will provide the certainty and insights they seek. As for me ... when I was ten years old I would

spend *hours* sitting on the floor of my grandfather's office in Scottsboro, Alabama trying to figure out a pattern in the tiny letters and numbers of a week's worth of the newspaper financial section. Today I catch myself spending *hours* staring into the abyss of a Bloomberg screen, just as hopeful as that ten year old boy was that the secret to cracking the code is juuuuuust beyond the corner of my eye and will reveal itself if only I look a little harder.

We all have our reasons for whatever approach we use to transform a profoundly probabilistic world into one that makes more sense to us, some combination of personal experiences and attributes that has molded us into whatever sort of tell-seeker we might be. I've found that many of the guys who spend all day on the phone are actually really good at finding connections and patterns within the conversations they have. I could never do it, but they can. Similarly, I can look at disparate data series and find connections and patterns that most other people can't. We all have our successes in whatever approach we use, which is why we stick with it, and most of us can appreciate the fact that what works for me might not work for you. Or as Hemingway wrote, "There's no one thing that's true. It's all true."

But we all have our failures, too. When our tell doesn't work – when it's not useful in generating the investment outcome that we had hoped – our reaction is almost always to find some fault in our chosen tell-seeking process, some manner in which we made a mistake in our analysis and can improve on it in the future. We are like Boxer the work-horse in *Animal Farm*, responding "I will work harder" to every set-back and challenge. We are like Mike in *Rounders*, dusting ourselves off from a poker beating at the hands of Teddy KGB, determined to think harder and look more closely to find that magical tell that will bring us the big score the next time we sit down at his table. That didn't work out too well for Boxer, and Mike's vindication was something you're only likely to find in a Hollywood ending.

Here's the non-Hollywood truth. There are so many of us looking for that magical tell, so many of us working harder at finding patterns in every corner of the public markets, so many of us employing machine intelligences that can ferret out patterns we would otherwise miss, that the half-life of any new tell we might find is shorter and shorter and less and less effective. Also, and this is a critical point, **obtaining private information on public companies has been largely criminalized today**. Since the SEC's adoption of Reg FD in August 2000, any investment perspective based on "getting to know management really well" has skirted the borders of legality, but it was really the Justice Department's mid-2008 adoption of Big Data tracking and direct surveillance methodologies that lowered the boom. Firms that institutionalized this private information perspective in particularly brazen ways are being prosecuted

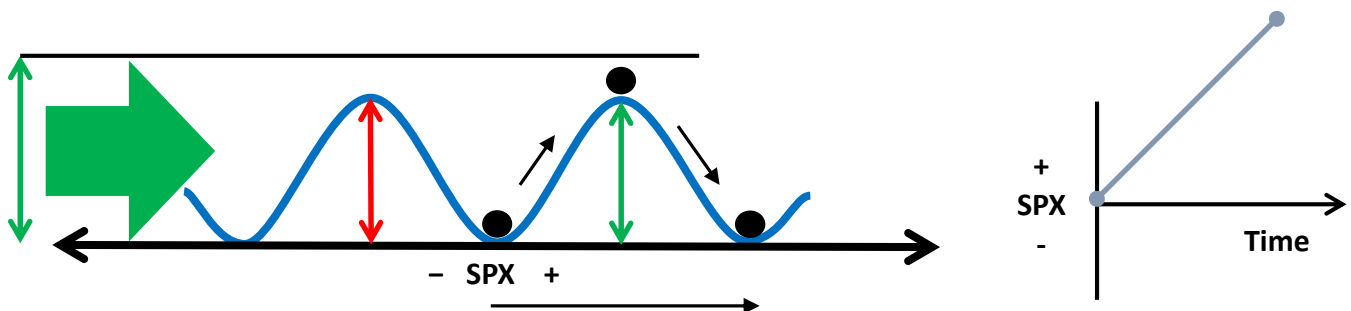
criminally, but every investment firm that relied, at least in part, on a private all-safe signal from management in making its risk/reward calculations (and let's be honest, that describes virtually every institutional stock-picker pre-Reg FD, and plenty of stock-pickers post-Reg FD) is feeling the alpha pain. From an informational perspective, the structural market impact is immense, as are the behavioral implications. When everyone has access to the same public information and trillions of dollars are at stake, you can be pretty darn sure that whatever pattern you may have inferred from the public data is not a unique observation to you. Every trade is a crowded trade today, and that's a major reason why game-playing behaviors are so rampant and alpha is so scarce.

So what's the answer to the problem of shrinking tells, crowded trades, and structural alpha scarcity? **As a starting point, we have to accept the fact that other investment or allocation processes are valid ways of making sense of risk/reward probabilities.** I'm not saying that we should jettison our preferred sense-making process in favor of someone else's process. Just because all investment perspectives may be true for someone does not mean that any investment process is true for everyone. The problem, though, is that we go well beyond simple non-adoption of alternative investment perspectives ... we reject them out of hand. Anyone who's been in this business for more than a nanosecond knows what I'm talking about. Macro guys dismiss stock-pickers (and vice versa). Investors dismiss traders (and vice versa). Quants dismiss everyone else in the world (and vice versa).

This is idiotic. Or to be more charitable, this is a terrible waste of available informational resources. If you accept that my methods of understanding risk/reward probabilities work for me (sometimes) and I accept that your methods of understanding risk/reward probabilities work for you (sometimes), **we can use the common language of Information to express each of our perspectives and allow you to incorporate my signals into your perspective and vice versa.** The answer to the problem of alpha scarcity is not to hope against hope that your tell will dramatically improve if only you work harder at it, or that you will suddenly discover some magical tell that will let you break the bank of your personal investment version of Teddy KGB. The answer is certainly not to flit from one alpha factor to the next, or to create some sort of multi-strat platform or portfolio where you simply cobble together these siloed perspectives within some artificial construct. In fact, a simplistic multi-strat approach can make the problem worse by slapping on a veneer of modern portfolio theory and masking the construct's inherent informational weakness. The answer, I believe, is to take whatever investment or allocation perspective you believe in, because I bet that it works for you and that you're pretty good at it, and improve it by incorporating additional signals from other investment perspectives.

Here's an example of what this *combinative signal process* for improved risk/reward assessment might look like in the context of single-stock selection, although the framework is equally applicable to any security or asset class.

First, let's start with a generic informational surface representation of a stock's risk/reward profile. This sort of representation is described fully in "[Through the Looking Glass](#)", but the basic idea is to think of price as a decision-making equilibrium at a given point in time (the solid black ball), where informational barriers (the trough walls) must be overcome in order for the price to "roll" to a new equilibrium point in either direction. The height of the trough walls represents the strength of the new informational signal (the green arrow) required to move the price to a higher equilibrium position. Importantly, this representation assumes nothing about where that new informational signal comes from, only that it is useful in changing some investor's mind about the expected utility of an exposure to this security.

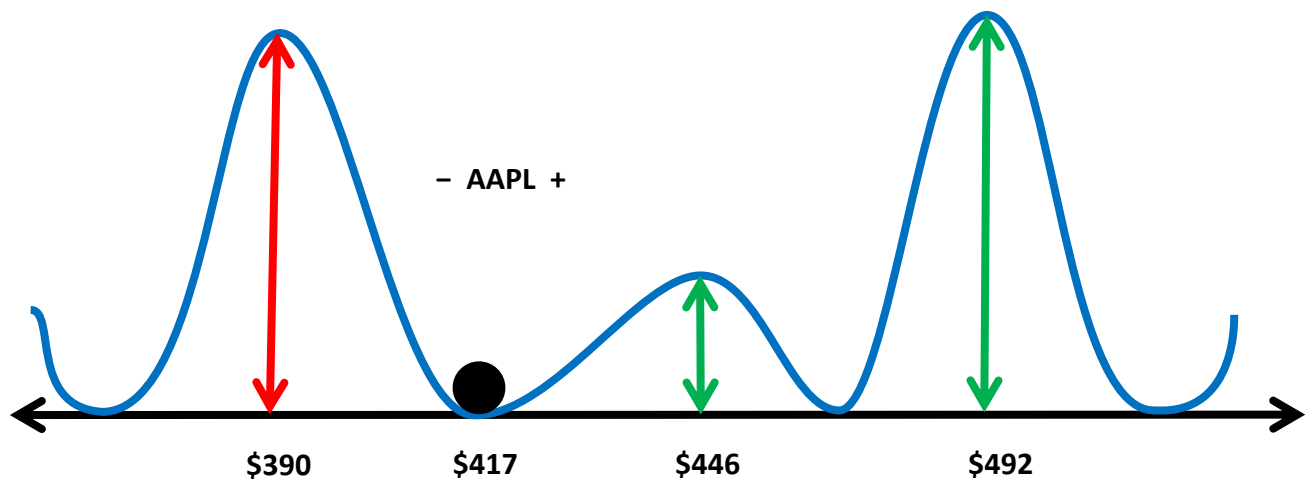


Now let's use the trader's perspective of technical analysis to take behavioral patterns from historical price information and update the generic informational surface. I'm starting with technical analysis as a source of additional information because it's so easily calculated from public information and is immediately familiar to most readers, but it really doesn't matter what perspective you begin with or in what order you layer the information. For a full description of the approach, see "[The Music of the Spheres](#)", but the idea is to translate resistance and support levels as expressed in price into price equilibrium barriers as expressed in information.

For example, if the resistance and support levels from a MACD technique for Apple (NB: these are entirely hypothetical levels and are not intended to be methodologically accurate) look like this on a traditional price/time chart –



– those same insights into Apple’s risk/reward probabilities can be expressed like this on an informational surface:



Why is this informational surface a better representation of the same technical analysis? We have transformed binary or categorical thresholds (resistance vs. support, strong vs. weak) into 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 with Big Data tools and machine intelligences to measure the informational strength of new signals, it’s possible to estimate the likelihood that this new signal will be sufficient to pierce the \$446 resistance but that new signal will not.

Let’s say that you have a fundamental view on Apple’s earning power and how and when that view will be revealed. Use that to modify the TA-derived informational surface, either formally with a Bayesian calculator or informally by just moving the curves around. You can be as quantitative or as qualitative with your use of this perspective as you like. But you can’t just wave your hands at your own informational assessment and expectations of Apple stock. If nothing else, this perspective forces you to examine your own tell-seeking process and express it rigorously in probabilistic terms of risk and reward. What are the signals you expect to occur regarding Apple’s earning power and why do you believe they have informational strength greater than the informational barriers indicated by technical analysis? What do you believe the probability distribution of these signals might be? Does the joint probability distribution of these signals and the current information surface give your exposure a positive expected return? If yes, is it a small chance of a large return or a large chance of a small return? How does that fit with the risk/reward profiles of the other exposures in your portfolio and your overall business risk tolerance?

Once you get the hang of this, there is no effective limit to the number of investment perspectives that can be translated into the language of Information and incorporated into the informational surface. Importantly, you can take this representation out into a third dimension and incorporate time-related sources of potentially useful information such as implied volatility data or your qualitative assessment of the outcome of some future event. The farther out you take the surface into the future, the more blurriness you have to incorporate into the ultimate risk/reward analysis, but there are well-established statistical tools to handle this. It’s also easy enough to weight one informational source more than another, again with a Bayesian calculator, if there is a meaningful difference in your confidence in the usefulness of one approach rather than another.

The penultimate point here would require a lot of math to make fully, and I won’t burden you with that, but will try to illustrate it with an old poker saying: if within 30 minutes of sitting down at a table you don’t know who the sucker is ... it’s you. **This is a sucker-free methodology.** Because this combinative

signal process is making better use of public alpha information – i.e., useful information is being shared among active investment managers and allocators, not found or revealed to the preferential benefit of any participant – the joint utility function of all participants is improved in a pareto-superior fashion. That's a mouthful, but it means that for active investors this is a common language where everyone can be better off, not a poker game. This process won't give any of us a better individual tell. But it gives all of us improved odds against "the market" and passive investment strategies, which is where the zero-sum poker game exists.

A final point: incorporating every possible informational signal from a wide range of deterministic processes is the foundation for everything else we can do subsequently to improve investment returns by navigating the stochastic ocean more effectively. And there's a LOT we can do here. Putting all of our signals into an informational framework makes it easier to appreciate the inherent probabilistic blurriness of future security prices, but there is still a right way and a wrong way to make these risk/reward assessments, and without the right tools and perspective as guardrails it's very easy for human decision-makers to go down the wrong path. Similarly, putting these blurry things into a collection or portfolio of blurry things has its own pitfalls (see "[The Tao of Portfolio Management](#)"), and there's a right way and a wrong way to navigate these particular stochastic depths. At the end of the day I think that Epsilon Theory can provide a coherent investment perspective around probability and information theory – a tool kit – that any active investment manager can use to carve excess returns out of the passive investment behemoth. This isn't a perspective for macro investors or fundamental investors. This isn't a perspective for quantitative investors or qualitative investors. It's a perspective for intellectually rigorous investors and allocators of whatever stripe who want a range of tools for making better decisions under pervasive and unavoidable uncertainty, all based on a re-framing of our perceptual processes in terms of their most fundamental building block: Information.