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Investing Is a Science

Seek simplicity, and distrust it.

—Alfred North Whitehead

. . . but somebody said, "I don't believe it," and we had an interesting conversation because I said, "You don't have the option not to believe. Believing is not optional. If you accept that this is replicated science, then belief is obligatory."

—Daniel Kahneman[1]

If we want to see investing clearly, one of the first things we must do is view its foundations—the ideas investing is supposedly built upon. This first chapter is going to be a doozy. In it, we're going to take a careful look at science and mathematics—two subjects that serve as the foundations of modern knowledge, especially for investing—and debunk them. Well, not fully debunk, really. More like cast serious doubts on them both as panaceas for investing knowledge.

Math and science are, at their core, philosophies. They are ways of seeing the world; they are not some rules about the world we've

discovered. I realize that will sound blasphemous to many. But as we uncover the inherent limitations—and benefits—of math and science, much will be uncovered about how exactly stock markets and investing work.

APOLLO'S ARROW SHOT CROOKED

In the Greek Pantheon, Apollo was the god of reason. He represents light and the sun, truth and prophecy. He carries a bow and arrow—a master archer—and shot straight and true. He is an oracular god—the bringer of truths and clear vision.

And Apollo lives today! His spirit pervades the western world, dominating our way of thought through math and science—our religions of the twentieth and twenty-first centuries. Science and math are great things. But we put far too much faith in them. Like all methods, philosophies, and theories, there are flaws. Math isn't perfect; science can skew us. The limitations of both are prevalent in investing.

I call science and math "religions" because they tend to conjure a kind of faith in us. We "believe" they give us truths about the world as if they are an eternal set of rules we've discovered. Today's hyperrational faith has led many to believe in a deterministic, predictable, clock-like universe that always moves in a straight line according to set rules. We only need to discover them. As a culture, we tend to bow at the altar of science the same as Greeks bowed to the Oracle at Delphi or prayed to Apollo thousands of years ago.

Math and science are great things, but they're not worth our undying faith. That's the Apollonian impulse. Instead, it may be better to think of them as excellent methods of describing what happens in the world.

Most investment knowledge is predicated on math and science. This chapter won't dismiss either, but it will provide a different perspective to help us see both in a way that helps us invest better. They are not religions, but useful ways of seeing the world sometimes by breaking down or

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contradicting reality. Good science holds skepticism as its highest value—that is what we wish to cultivate. Even to be skeptical about science itself! Often enough, mathematical theories contradict or compute results that simply do not translate into reality. As neuroscientist Jonah Lehrer said, "No truth is perfect, that doesn't mean all truths are equally imperfect." The findings of science are the best we have at objective knowing, but that doesn't mean they are a panacea.

Sometimes, Apollo's arrow of knowledge is shot crooked.

DIONYSUS—MORE THAN JUST A GOOD VINTNER

Somewhat in opposition to Apollo, there was always Dionysus. He is the god of wine, the inspirer of ritual madness and ecstasy, the messiness of life and its sometimes chaotic nature. Dionysus represents that which we cannot compute or rationalize but nevertheless is. He is the "liberator" from pure reason.

Dionysus was a popular Greek deity, but in today's world he's pushed to the fringe—the god of wine and frivolity, fun and spirits. (Many know him best by his Roman name, Bacchus, the root of "bacchanalia.") We dare not let him into the fray of our work or allow him to dwell in the investment world—he might disrupt this rational and ordered territory we believe in so deeply!

If we cut the brain down the center into two hemispheres (right and left), we'd find that differing sides serve different functions—reason on one side and creativity on another. (This is, of course, a gross generalization and both hemispheres hold parts of each, but nonetheless is generally true.)

The left brain is traditionally logical, sequential, rational, analytical, objective, and tends to break things apart to look at the constituents instead of the whole. The right brain is more intuitive and holistic (it sees things as a whole instead of parts, synthesizing and subjective). The right brain is where we think abstractly, where the imagination resides. The right's flighty creativity can be disruptive to the left's desire for rationality. Today, most believe Dionysus—the

messiness of creativity—is a figure to be *overcome*, not embraced. But this is wrong—both the creative and the logical are valid and important modes of thought for investing.

We tend to favor one side over another, but most everyone has the capacity to utilize both. Thinking with both sides of the brain can readily create paradoxes—we can see things as a whole, or just the parts; we can see something rationally, or colored with imagination. We can see things from many perspectives. So the brain itself is capable of these different ways of thinking and can create its own paradoxes.

The distinction between the right and left brains is something like the problems between Apollo and Dionysus. Taking in as many viewpoints as possible and assimilating them all is the way to better thinking and investing—it is the heart of true inquiry. Throughout this book, we will attempt to shift perspectives and see things in ways many fail to.

We ultimately cannot reason very well without Dionysus. Abstract thinking, imagination, and creativity are not paltry things—they are essential for good investing. We cannot, nor would we wish to, be computers. There is no advancing of thought or discovery of new things without the imaginative component and the ability to change perspective. No inspiration for new investing paradigms ever came without a dose of imagination.

Investors tend to have a near dogmatic belief that purely left-brain thinking is the optimal way to approach investments—check the data, run the analysis, and so on. This is true enough insofar as it goes. Market analysts are usually hyper-developed in the logical modes of linear thinking. But it's very much worth noting those usually thrown into the "genius" category were highly developed creative thinkers too. And we're not talking about artists—it's true for the sciences as well.

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My favorite examples are physicists: Carl Sagan, Richard Feynman, Albert Einstein. In particular, I have read Richard Feynman's autobiography, *Surely You're Joking, Mr. Feynman!*, many times—whenever

I need to remember the importance of developing many types of intelligence to be good at what I do. Mr. Feynman, along with being a Nobel-winning physicist, also was a painter and noted player of the bongo drums. Carl Sagan was well known for the almost child-like wonder and glee he got from contemplating the possibilities and mysteries of the cosmos.

In any case, what separated the great physicists from the pack wasn't the mathematics they knew (they all at least had a few peers in that), but their creativity. Each had an uncanny ability to imagine and associate their knowledge, to put ideas together in ways no one had before and create new insight. Einstein himself often regarded his imagination as tantamount or superior to his rote math skills. (Of the many biographies of Einstein out there, I prefer to read the quirky but fascinating writings from the man himself: *The World As I See It* and *Ideas and Opinions* are two good options.)

Einstein was a terrible investor, but his method of thinking holds true for investing. A dirty little secret about great investors is that they're all tremendously creative thinkers. It rarely looks that way to the public because most put on airs of being rigid, starched, disciplined, linear thinkers. After all, most folks want nothing but the most "computer-like" minds to manage their money! But the fact is, the only way to get an insight—to know something others don't know—is to have huge and deep creative thinking about the world that must—by definition—defy convention.

The fruits of creativity (new ideas) come less often from some sudden insight (as we tend to romanticize it), but rather from many small insights building upon one another after many thousands of hours of labor and thinking.

USE THE METHOD, NOT THE DOGMA

That said, if the behavioral sciences have taught us anything, it's that our natural brain wiring can cause biases and distorted views of the world. This is sometimes referred to as the issue of *grounding*, which means if we know our senses can deceive us, how do we know where

deception ends and truth begins? How can we "ground" ourselves to a clear perspective? Do our brains deceive us about everything? Or just a few things? If we could just get some foothold on reality, perhaps we could be grounded enough to be both rational and objective in their due course.

Here is where science comes in. The best answer we have to the problem of grounding is science. Science can provide us that "foundation" of knowledge, revealing to us through experiment and objective results, verified over and again, how something works in the world. It's the method of science that we are after to become better investors, not its dogmatic claims to truth.

I Think, Therefore I Invest

Most have heard of Descartes and his famous proclamation "I think therefore I am." Philosophers call this turn of phrase the *cogito*. Either way, it's an important statement for how scientific thought is done. Particularly for investing methodology, the cogito is the foundational statement of *objective thought*.

Objectivity is the opposite of subjectivity. Subjectivity is the idea you can only see things from your point of view, with your own personal biases and ego. We are stuck inside ourselves—there's no other way to see things except through our own eyes. That's a problem because we know biases and emotions can sabotage our thinking and lead us to act wrongly. Neuroscientists have known for years we can't think without emotion—all thinking has emotion wrapped up in it in some way. This means we cannot surmount subjectivity since we cannot escape our brains. So how can we go outside ourselves and surmount our inherent subjectivity?

Descartes was among the first to make a formal statement attempting to separate oneself from the world and acknowledge the world inside our heads and the world outside our heads is different. This is *objectivity*.

Why is objectivity important for investing? It forces us to acknowledge a framework outside our biased and subjective selves—the

point of the scientific method. Science helps us systemically and objectively (as possible) attack problems.

I know of no investing success story—ever—that achieved riches by trusting intuition and emotion over the long run. But I do know the world is chock full of many who got poorer that way. Your brain needs a system or framework that disallows personal biases and intuitions to interfere. We should strive to be as objective as we can be about how we observe the world. The framework you set for yourself will influence all your conclusions. Academics sometimes call it heuristics (more on this in Chapter 8). I just call it clarity.

The Scientific Method

Descartes may have brought us a long way in articulating objectivity, but just what is it exactly in the real world? Is it following the right procedures? Is it an attribute of the person—like emotional detachment? Luckily, Francis Bacon had an answer.

Bacon wrote the *Novum Organum* (Latin for "New Instrument") in 1620. Many considered Bacon a philosopher, but he didn't propose a new philosophy—rather, a new method of thinking and gaining knowledge. He deemphasized human intuition and feelings, asserting that one should proceed through inductive reasoning from facts. He wrote, "The cause and root of nearly all evils in the sciences is this—that while we falsely admire and extol the powers of the human mind we neglect to seek for its true helps."

Bacon declared that the thinker must free the mind from certain false notions or tendencies that distort the truth. Bacon called these "idols." He named four types of idols, or biases, a person can have:

- **Idols of the Tribe**: These are biases all people have—natural, inborn instincts. For example, fear is an emotion, arising in everyone in the presence of danger.
- **Idols of the Den**: These are beliefs a person comes to believe on their own through subjective experience. People often mistake their personal experiences for the larger whole.

- **Idols of the Marketplace**: These are biases that stem from the misuse and misunderstanding of language and other forms of communication. (Think about it, we misunderstand each other through e-mail and speech daily!)
- **Idols of the Theatre**: These result from an abuse of authority where people are led to believe dictums of the state by virtue of authority, not facts. Very often, we believe something simply because it is the law or is widely accepted.

Perhaps you think you're immune to these, but you'd be wrong. We all suffer from such biases and many others—this is really only a partial list. But in Bacon's day it was wildly innovative. From these ideas came the *scientific method*, emphasizing objective observation and outside corroboration of ideas.

The scientific method is, by far, the best human technique for acquiring new knowledge, as well as for correcting and integrating previous knowledge. It is based on gathering observable, empirical, measurable evidence. Here's the method:

- **Observation**: All data must be based on verifiable and observed facts. No assumptions.
- **Prediction and Hypothesis**: Information used must be valid and consistent for observations past, present, and future. That is, anomalies in data need to be identified and everything should be "apples to apples" so that it is comparable.
- **Control**: Actively and fairly sampling the range of possible occurrences, whenever possible and proper, as opposed to the passive acceptance of "opportunistic data," is the best way to counterbalance the risk of empirical bias.
- **Falsifiability**: This is the key to identifying much popular pseudo-science. This is a gradual process requiring repeated experiments. One must be able to replicate results in order to corroborate them. This means all hypotheses and theories are, in principle, subject to disproof. A theory must be falsifiable, otherwise it is not scientific. Many investment studies wrongly

assume answers and then seek to corroborate that notion with data—very dangerous because there are many ways to make data bend to your will.

- **Identification of Causes**: Identification of the causes of a particular phenomenon to the best achievable extent. The causes must correlate directly with observed effects. It's not enough to just observe something; one must be able to explain it. No correlation without causation—many things are related by coincidence.

This may seem simple, even trite. But folks succumb to their "idols" more often than we care to admit. That's because our idols are close to our natural proclivities, but science requires discipline and isn't natural to us.

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Sadly, few think to apply the scientific method to investing. From this simple framework, an investor can obliterate false notions and see through common fears and widely held (but wrong) beliefs. To be a successful investor, one must be a scientist, not an idol worshiper. Bacon says it best:

> Men have sought to make a world from their own conception and to draw from their own minds all the material which they employed, but if, instead of doing so, they had consulted experience and observation, they would have the facts and not opinions to reason about, and might have ultimately arrived at the knowledge of the laws which govern the material world.[2]

Theory and Reality

Generally, investors shouldn't make a trade unless they can observe a phenomenon in reality and also understand why it's happening. Without both corroboration of the data and a reasonable explanation (AKA a theory), big trouble can ensue.

Trading on theory alone is fraught with danger. Many defunct investing ideas make perfect logical sense in theory, but never worked

in real life. Conversely, an observed pattern without an understanding of why it's happening is also problematic.

It's best to never act on an idea without both correlation and causation. A correlation is just a mathematical way to describe the degree of association between two variables—not a way to explain *why* the relationship is happening. There are many random correlations that are simply coincidences. A coincidence doesn't have predictive power and can lead to *false positives*, or thinking there is a meaningful relationship between two things when really there is not.

A classic investing example is the way many compare today's price-to-earnings (P/E) ratios to some past period and try to predict where stocks will go. It makes intuitive sense that relatively "high" P/E ratios should predict lower stock returns in the future, and vice versa for "low" P/Es. But reality has shown over and again this isn't true.[3] P/E levels have never been predictive of stock market direction.

Additionally, one could run thousands of correlations between P/E ratios and other economic factors like interest rate movements, changes in accounting rules, capital structure ratios, economic cycles, future earnings expectations, and so on. The sky's the limit! Heck, you could run a correlation between divorce rates and P/E ratios if you want. Many will produce a positive correlation. But that doesn't mean we ought to use them to invest with.

Even the seemingly objective process of experimentation and testing can create biases in our thinking. Just the act of focusing on something influences how we perceive it—spending a lot of time on something can unconsciously make us believe it's more significant than it might really be. You can take anything, however small, and amplify it by focusing on it—precisely what experiments do.

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The Only Worthwhile Philosophy Is a Pragmatic One. One time I asked my boss Ken about "other intellectuals like himself." He didn't answer the question. Instead he said, "I am not an intellectual." And that was that. I was incredulous. I smiled a little, thinking he had to be joking. He was not smiling back.

That was an important lesson for me. Ken's stance wasn't some far flung personal bias—it was an important professional attitude. Intellectuals entertain all sorts of flights of fancy, existing in worlds where reality doesn't necessarily ever need to come into the picture. Believe it or not, most all mathematical research is done explicitly in a reality that does not exist—it may only "hypothetically" exist. There is nothing wrong with that—living and thinking in a world of abstraction can produce important advancements in knowledge.

But Ken, as a money manager, is explicitly in the business of reality—focusing on how the world demonstrably really worked—not how he (or anyone else) thought it worked or believed it should work. That is an attitude, I've come to learn, successful investors share.

Thus, philosophical systems don't usually have a very strong place in a good investing strategy simply because they're so, well, airy. But there is at least one I think is worth consideration. William James—known as a pioneer of psychology—was also a leader in a philosophical idea called Pragmatism in the late nineteenth century. Its founder was Charles Peirce, who created the *pragmatic maxim*:

> In order to ascertain the meaning of an intellectual conception one should consider what practical consequences might conceivably result by necessity from the truth of that conception; and the sum of these consequences will constitute the entire meaning of the conception.[4]

Pragmatism says a theory is only worth the effort if it helps us understand reality and the world better. Now that's a philosophy I can get into!

For example, Irving Fisher's theory for the quantity of money is stated mathematically as $MV = PQ$. This powerful equation describes

Reverse Engineering for Better Investing

Scientists regularly solve problems with the principle of reverse engineering (RE). This is the process of figuring out how something works by analyzing its structure, function, and operation. That is, you figure something out by seeing how it works and then work backward to find the principle causes of why it works that way. Scientists often use RE to analyze mechanical devices—using RE as a method of reducing a problem to smaller parts.

I don't think this kind of reasoning is advisable or even possible for investing, but I do have my own alternative types of RE to use.

Type 1: If something is true one way, the reverse usually ought to be true.

For example, many folks believe a weak dollar is bad for the stock market. If it's true, then the reverse ought to also be true—a strong non-dollar should be good for stocks. Right? Well, hopefully just by framing the question in this way you can see how ridiculous it is. There's no good reason a strong non-dollar should be good for stocks any more than a weak dollar would be bad. The simple act of reversing a problem in this way often reveals—almost immediately—how flawed investor logic can be. In fact, the data bear this out—neither a strong nor weak dollar has much correlation with performance of the global stock market over time.

Type 2: Observe how the system works, not the parts.

Stock markets and economies don't often work in simple cause-and-effect relationships. Moreover, the micro, or local, behavior of an economy doesn't necessarily add up to how the whole system might function. So instead of watching an economy's smaller parts and trying to glean how the system works, observe the system itself. The patterns of the larger economy and market are often different than the behavior of individuals acting in that system. That may sound a bit obtuse. In Chapter 5 we'll cover this idea in greater detail.

In both cases, reversing the process and/or viewing the system itself are effective tactics for investors. Or, as Sherlock Holmes (that is, Sir Conan Doyle) says in "A Study in Scarlet":

> In solving a problem of this sort, the grand thing is to be able to reason backward. That is a very useful accomplishment, and a very easy one, but people do not practise it much. In the everyday affairs of life it is more useful to reason forward, and so the other comes to be neglected. There are fifty who can reason synthetically for one who can reason analytically.

the relationship between inflation, prices, and the money supply, and offers us better understanding and insight about the process. But the big error is people want to use it to describe reality. Yes, Fisher's equation helps us think through how—in an isolated and abstract way—money flows. But to actually try and calculate it is a nightmare. There are too many assumptions and other potential affecting factors in the real world to ever come up with a reliable calculation. That's the pragmatic part—separating the theory from the reality. Most theories are there to help us understand a perspective, not perfectly predict a very messy and noisy world. Be pragmatic!

CAREFUL WITH CATEGORIES

How do you categorize things? Most never think much about it save for organizing their file cabinets once a year, but our categories say a lot about how we see the world and it's a fundamental activity of the sciences.

All sight is done through a lens of some kind. That's literally true (eyes, electronic or organic, all have lenses), and it's also figuratively true. Brains have a natural tendency to create lenses to bring the world into focus by making *categories*. We are categorization machines, constantly looking for similarities and patterns to lump things together. The kind of lens (or category) used, then, can make all the difference in how we see things. This gets treacherous because our minds want to create categories unconsciously—without our knowing. Bad categorizations cause big biases in investing and life generally.

Here's a fact: There is no such thing as a category in the natural world—humans make them up. A category is a not a thing, but a way of seeing things. That makes your choice of categories all the more imperative because *categories are really more about interpreting the world than they are about seeing reality*.

Sound strange? Let's take an example.

There is no such thing as a "species" of animal. Think of a bear. What is a bear? What makes it "bearish" (bad market pun intended)? Is it the claws? Nope—bears of the world have many different types of

claws and some not at all. Many other animals have claws, too. Fur? No—just as various. Muzzle? Hibernation? Bone structure? No! There is no one characteristic of a bear that actually makes it a bear—every single trait (or *phenotype*, in science speak) varies among regional types of bears. Heck, big brown bears are in many respects closer to other warm-blooded animals than they are to pandas.

There is little real consistency across various types of bears. To call them all bears was our choice. In truth, every animal is a completely singular cluster of DNA that will never be exactly repeated. There are only similarities. As a result of genes mixing over time, what we call a species today won't last for more than a few million years anyway and eventually evolve into something slightly different. We simply use "species" as helpful categories to see and delineate life's different forms at this specific moment. "Bear" is just our way of describing similar animals in the world. So, categories are really useful to help us make sense of the world—but they are perspectives on how we view the world, not an appraisal of reality.

The same is true for markets. There are many long-held categories in markets—ways of slicing and dicing stocks to see them clearer—that are simply wrong and lead to investing mistakes.

An example is the division between small and large cap stocks. There are industry "standard" ways of computing what is "big" and what is "small" that most folks adhere to without thinking twice about it. Most portfolio managers consider small cap stocks something below $10 billion in market cap or thereabouts. Sometimes $5 billion or less. In any case, it's almost always an arbitrary distinction.

In certain parts of a market cycle, it's believed small caps will outperform large caps, and vice versa. But there's no way to get that right if the categories are wrong in the first place.

What seems "big" usually isn't. Instead of the arbitrary $10 billion or $5 billion distinction for small caps, a better way is to take the weighted average market cap of the whole market. Anything bigger than the weighted average should be big, and the rest should be small. Those are better categories for viewing the investing landscape because they are "grounded" (recall the problem of grounding and

the scientific method a few pages ago) in reality and also in the context of their peers (other stocks), not an arbitrary distinction that seems "big" to us.

It turns out a very small number of companies are truly "big"—that is, actually bigger than the weighted average. The vast majority are smaller—and guess what, they tend to act "small," too! In market cycles, it's only the mega-big stocks that act "big."

As of this writing, the weighted average market cap of the S&P 500 is $78.8 billion. That means many stocks we'd traditionally consider "big," like eBay, Gap, or Nike, actually act rather small.

The point? Before we can do any cogent analysis, we ought to check our categories first and make sure they aren't biasing us in ways we hadn't before imagined. It can make all the difference between a right and wrong conclusion.

COULD MATH BE WRONG?

There are two kinds of people in this world: Those who believe math is the discovered law of the universe, and those who think math is a human way of describing the world. I fall into the latter category. I think all investors should.

Math is maybe the greatest of all human inventions. Yes—invention. It is an invention with near countless possible uses, but it also has problems and limitations. My aim isn't to say math is bad. It's great! I just hope to show you a good investor won't trust numerical equations as religion—there is much more to markets than math is capable of describing. George Lakoff and Rafael Nunez, in their fascinating and often brilliant study of how human minds understand math, *Where Mathematics Comes From*, argue persuasively math is a feature of the mind, not reality.

> Mathematics is seen as the epitome of precision, manifested in the use of symbols in calculation and in formal proofs. Symbols are, of course, just symbols, not ideas. The intellectual content of mathematics lies in its ideas, not in the symbols themselves.[5]

What strikes me most about that passage is the archetypal way Apollo and Dionysus are clashing—this is the classic "imagination versus reason" conflict renewed.

Part of the dogma of science is a tacit but widely held belief math is something we humans "discovered" about the world. That math is in everything, and all we need to do is "find" the right equations and we can explain and know everything about how the world works. Many believe observing the Fibonacci series in flowers and logarithmic spirals in snails proves math is reality. Even most formal logic is structured around math! To learn math is to learn how nature works, and it would be shared by any intelligent life in the cosmos—the universal truth!

So the story goes.

Maybe, but I think mathematics for investors is better used as a kind of philosophical, descriptive system than a rule book. Math is a way to comprehend the world around us in ways our brains can handle—a way to describe the world. Math often mirrors nature, yes, but very often it falls short or is contradictory to reality as well. Talk to any student studying for a math PhD (and, believe it or not, I've conversed with a few), and they'll immediately tell you math is not reality, but a "rough approximation of reality."

What's the point for investing? Our aim is to find the right perspective to invest successfully. Dethroning math from its godlike perch will make you more dubious of statistics and "verified" results. That's a good thing. No matter how often "science" might corroborate something, the fact is we can only corroborate things in ways intelligible to us. Good scientists know asking the right questions is more important than having the answers. Often, we don't even know how to ask the questions because there are many features of markets and economies outside our ability to comprehend.

No amount of math as it exists today is able to predict or even successfully describe how markets work. At best, some of the parts have loose theoretical calculations that often break down. Today's math:

Beware of Normative and Positive

One thing to be aware of whenever scanning investing news or thinking about investing decisions is the difference between a normative and a positive statement.

Normative: How something ought to be.

Positive: How something truly is.

For example, to say, "A weaker dollar should affect stocks negatively," is a normative statement about what someone thinks ought to happen. But a positive statement is, "Stocks moved higher in 2007 even though the dollar weakened." That is a falsifiable, verifiable fact.

The point? It's fine to think in normative terms—much of abstract thinking calls for it, and we often need it to think creatively and hypothetically. But when you're dealing with real money in the real world, normative statements can get you into big trouble. Essentially, it's the difference between what could happen theoretically or hypothetically and what really is.

Another example: Many folks believe in the "wealth effect"—the idea that if housing prices go down (or the value of any other personal asset), people will feel poorer, thus they will spend less, which will lead to smaller economic growth and less jobs for producing goods and services, which then leads to further falling home prices and lower income, and the cycle continues in a downward spiral on and on.

In theory (normatively), the logic of the wealth effect makes sense. But in reality, this cannot possibly be true. How to know? If it were true, any time asset prices fell they would cause a downward spiral we'd never recover from. But every time things like stock markets or housing prices have fallen, they've eventually recovered, as has the economy. This has always been true through time. The reality destroys the theory.

Normative thinking is fine and good, but always seek reality before making a decision or believing an analysis.

- Is reductive (more on this in a moment)
- Can generally only accurately deal with a few variables at a time and has difficulty with rising complexity
- Tries to achieve exactitude where none may exist in reality

For example, much of how we look at stock markets is done via charts and graphs. What's wrong with that? For starters, a line graph can only account for *two variables at a time*. Just two! Stock markets and economies have millions of variables interacting constantly.

Even when correctly used, math can distort reality. Darrell Huff's *How to Lie with Statistics* was written in 1954, but to this day is one of the best studies of how statistics can cause intentional and unintentional problems. I won't recount its content here, but I highly recommend it.

If you're not yet convinced math is a philosophy, consider this: Numbers are unnecessary to do math. Numbers are an afterthought, a kind of symbol that can be plugged into equations. Most math PhDs never even use numbers, they just use symbols. Math, at heart, is a self-contained system of logic, not a depiction of reality.

As a brief, real-world example where math failed, let's look at the infamous casualty (and oft thought catalyst) of the 1998 financial crisis—Long-Term Capital Management.

Where Math Failed: Long-Term Capital Management

Long-Term Capital Management (LTCM) was a prominent hedge fund founded by a handful of financial bigwigs, including John Meriwether (former vice-chairman and head of bond trading at Salomon Brothers), Nobel Prize winner Myron Scholes (the economist credited with developing the "Black Scholes" options model), and Robert C. Merton, also a Nobel Prize winner in Economics.

The fund used complex mathematical models to take advantage of fixed-income arbitrage opportunities and employed huge leverage to make profits. Sometimes called *convergence trades*, profits on individual trades were small, so the fund took big leverage positions to grow profits. At one point in 1998, LTCM had borrowed over $124.5 billion and carried a debt-to-equity ratio of about 25 to 1.

For a time, the fund reaped huge profits based on its purely mathematical investing techniques, with over 40 percent returns after fees in its first few years. But in 1998, LTCM lost nearly $4.6 billion in the span of just a few months as the financial crisis in Asia took hold—a so-called *exogenous* event.

The failure was so huge, the Federal Reserve was forced to initiate a bailout of LTCM by other major banks—all because the mathematics

behind LTCM's strategy couldn't ultimately account for certain unpredicted events. In other words, math failed to account for reality.

If you want to learn more about LTCM, read *When Genius Failed: The Rise and Fall of Long-Term Capital Management* by Roger Lowenstein. Later, in Chapter 9, we'll explore other failed mathematical attempts to understand risk and discuss the infamous "Value at Risk" (VaR) equation partially responsible for the 2008 financial crisis.

REDUCTION: WHY YOU CAN'T QUANTIFY EVERYTHING

Equations and models can predict how a machine will work, but living things have properties that cannot be quantified.

Math describes much of the physical world quite easily—objects (usually inanimate) that are governed solely by physical laws. If you throw a football, all you have to know is a few variables like velocity and acceleration and gravity and you can pretty easily figure out where the ball will land. You can do the whole thing by using an equation and plugging in a few variables. Like a miracle, it will work every single time! Totally universal.

Another familiar mathematical dictum: If you solve each step, or part of the larger problem, eventually all those small solutions add up to the bigger solution. Think about a car as an example. A car is a big machine made up of a bunch of smaller systems—engine, air conditioner, power steering, and so on. When you put all the little systems together, you get a car. Same with the human body: Scientists commonly understand our bodies by reducing the problem to the smaller parts—systems like circulatory, nervous, skeletal, and so on. Or we can go even further and think about individual cells. If we can understand first how our cells work, then we can simply put all the cells together and then get to a solution about how the body works.

But complex systems like stock markets, which involve humans, don't behave like physical systems. Intentionality isn't the territory of physics. Minds, feelings, urges, thoughts—there is no set of mathematical rules (we know of) to explain them. But that doesn't stop

folks from perpetually trying to impose the logic of physical systems on complex systems like stock markets.

This typifies the scientific problem of *reductionism*. Part of the mission of the scientific method is to "reduce" big problems—separate them into manageable parts, small problems—that can be easily solved.

A bit of scrutiny reveals how damaging reductionism can be for understanding economies and markets, which very obviously do not behave in the same ways basic physical systems do.

Reduction Is Good!

Most science is predicated on the idea reduction is a valid way to solve problems. Math problems routinely try to break a problem down into discrete variables and individual parts. It's near ubiquitous dogma that the methods of reductionism can go hand in hand with investing. Most of today's economic and market models rely on sets of equations based on definable (that is, quantifiable and identifiable) variables. Just check out any economic textbook—you'll immediately see it's a field mostly based on mathematics and reductionism.

As we'll see in future chapters, some systems are too complex, dynamic, and interconnected for simple math—literally, the sum is greater than the parts. Stock markets and economies are such systems. There is no way to quantify many things in an economy. Math can indeed help explain and compute some of the parts, but never the behavior of the whole, and can almost never help in predicting what will happen.

But in some sense, reduction is the only reliable way we know to solve problems and is wonderful for many reasons. Our brains are limited, so taking small problems one at a time is a great thing. We tend to do very well with "steps," or taking problems in sequential order to achieve some larger goal. For instance, buy a tricycle for your kid and the instruction booklet will have "step-by-step" instructions on how to build it. That's reduction. One thing at a time and build to a solution. We naturally think this way. That science is accommodating

to our natural thought processes is great. But there are plenty of pitfalls with reduction, too. . . .

Reduction Is Bad!

The scientific principle of reduction is fine for many things, but leads to pitfalls in others—especially investments. Markets cannot be *reduced* to purely mathematical rules. There are no accurate math-based models to forecast how stocks will perform, and likely never will be. If you think about it, that's pretty intuitive: The value of things (especially for stocks, or anything economic) is ultimately based on the idea of "utility," or the perception of value. Perception of value is always and everywhere an arbitrary and contextual thing—a psychological thing. Which means a mathematical value assigned to it is fuzzy at best.

To see this, think about a human brain, which is a classic complex system. Reductionism says we ought to be able to understand how brains work simply by studying and understanding what brains are made up of—neurons, synapses, dendrites, and so on. Many neuroscientists have tried it, but all have failed! Understanding how neurons work may tell us much about the mechanics of brains, but it doesn't explain how the larger system creates consciousness, emotions, or thoughts in general. We have to study how the larger system works for that.

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Here are some additional problems with reduction and market analysis:

Linear Relationships: Much of science sees life as moving from point A to B, then to C, and so on. Linear, direct, straight. Cause and effect. Markets do not follow such patterns. They zig and zag and often circle around. For instance, economic outcomes seldom translate into stock prices exactly, or sometimes at all. Positive earnings releases don't always lead to an

up stock; GDP growth doesn't necessarily lead to an up market. Why? Because if anything were that predictable, we'd all be trillionares—investing would be too darn easy! Any possible real direct relationship gets priced in very quickly.

Correlation and Causation: This is related to the idea of linear relationships. There's a deep human need to see all things in terms of a clear cause and effect, leading often to "false positives." Brains are wired to seek relationships even if one isn't really there. A simple correlation—even if apparently hugely significant—on its own doesn't really hold much information. Markets are complex systems where millions of variables are dependent upon each other, so it's nearly impossible to analyze two factors discretely. You may observe an incredible correlation between, say, growth in US beer sales and times just before Eddie Van Halen enters rehab, but that doesn't necessarily tell you they are significantly connected. There could be an unforeseen third factor actually driving that relationship, or a number of outside factors. Maybe Eddie entered rehab during the Super Bowl—one of the biggest US beer consumption days of the year. Or it could just be a casual coincidence they happened at the same time. In markets, again, there are so many factors working upon each other at once, gleaning a true correlation that's consistently useful over time for predicting stock moves is quite rare.

The Simplest Possible Terms: Human brains love binary; that is, simple yes/no propositions. Gray areas mean ambiguity, and brains don't naturally like ambiguity. Yes/no is better to us. Reductionists often try to get to yes/no equations—to find a "trigger" for when someone should buy or sell stocks, for instance. (Entire firms are founded on so-called "quant" funds that specifically design mathematical models to generate such triggers. None have ever worked in the long run.) Indeed, science is often described as a way of seeking simplicity. For example, Isaac Newton's third law of motion—for every action,

there is an equal and opposite reaction—is elegant and simple. But it doesn't necessarily hold for markets (as we'll see in Chapter 5).

Reduction means getting rid of "gray" areas. It should be fairly obvious, however, that markets are not matters of yes/no, on/off. Subtlety and magnitude matter a great deal. Gray areas are actually more common than absolutes. Most financial math as it exists today cannot account for such subtlety.

The Desire for Elegance: Many scientists believe a simple, "elegant" solution to how the cosmos works must exist—it's just a matter of us discovering it. That tantalizing idea has driven scientific minds through all time and is part of the fetish of reductionism. This dates all the way back to Plato—who saw all things in the world as crude representations of a more perfect abstract "form"—and goes all the way forward to Einstein, who believed it was possible to find a single equation to describe the whole cosmos. There is no law or rule saying any investing solution must be neat and tidy or simple or beautiful—nor is there any rule that even says there must be a solution we can understand at all! Aesthetics don't count in investing.

Smaller Problems: Reduction wants to divide big problems into smaller problems that can be handled discretely from each other. If you want to fix a broken clock, you don't really have to think holistically about the whole clock. All you have to do is identify the part that's broken, fix that part, and integrate it back into the system. Clock fixed. But markets and economies don't work that way—most variables cannot be separated from one another or observed in a vacuum. The moving parts of a market have real-time effects on all the other parts. As one changes, the dynamics of the whole system change. So how all the variables interact matters a lot. Open up the *Wall Street Journal* on any day, though, and you'll see experts talking about "single" issues like interest rates or the money supply as

> if they were discrete from everything else. In fact, many factors both affect and are affected by interest rates—they simply cannot be understood on their own. This simple observation destroys the validity of most reductionist economic models.

Reducing the Truth Away

Now we've seen a bit of the good and the bad about reduction. Let's take an example of how this might translate into the real world of investing.

With any cutting-edge field of study, new ideas get thrown around wildly, and most conclusions are at best preliminary, but often wrong. Scientific theories take years or decades to vet—requiring testing and retesting before they're canon.

The mainstream media moves too fast for all that. Once the intellectual paparazzi gets a hold of a new theory, things tend to spiral out of control, ideas are often distorted and misconstrued, and scads of irrational conclusions are consecrated as scientific truths. This is often referred to as pseudo-science, or science-ism.

The investing community is not immune. Below is a quote from the book *Mobs, Messiahs, and Markets* by William Bonner and Lila Rajiva. It's a study using behavioral economics to analyze market behavior.

> What if all animals [and humans included] simply act according to various prefigured survival strategies, the purpose of which—as far as we know—is nothing more than genetic replication?

Seems reasonable. It's a riff on Richard Dawkins' theory of the Selfish Gene. Hearkening back to the mid-1970s, the idea posits that organisms act principally to replicate their own genes and enable survival of the species. Classic reductionist thought—a single principle to explain all animal behavior and ultimate motivation.

Bonner and Rajiva's book is full of useful and thought-provoking ideas, but there's a big problem lurking in their prose: Their representation

of the Selfish Gene is vastly over-simplified and too rigid to reflect reality. It's a classic case of misused reductionism.

By operating on the premise gene replication is the only rationale for animal behavior, science is sent backward, not forward. Representing humans as pure automatons of genome willpower is essentially a re-visioning of BF Skinner's theories on instinct and Pavlov's dogs. It isn't cutting-edge neuroscience; it's a cognitive U-turn back to the twentieth century!

Many new books and articles on economics and human behavior take a reductionist approach, and it's something to be wary of. Reductionism can thwart your investment analysis as fast as any basic miscalculation.

Just 10 years ago, scientists believed once the human genome was mapped, we'd hold the key to countless medical breakthroughs, which would occur in rapid succession and revolutionize all medicine. We accomplished that goal only to find things weren't so simple. No, the real keys to understanding human life had to do with the proteins those amino acid strings produced by DNA—in what measure, at what time, and in what combinations. So they did a bunch of work on proteins (and continue to). And we found it's not just protein synthesis, but protein interaction with the surrounding environment that's probably responsible for expression of traits. Put another way, understanding the most basic keys to human life turned out to be vastly more complicated and nuanced than just mapping DNA strands.

And so it is with understanding brains, too. The more work done in neuroscience, the more complicated things become. Every neuron is interconnected and dependent upon other neurons—interconnections so vast and intricate that simply understanding how the brain "sees" an image captured by the eye is enormously difficult.

Simply, understanding humans—from the molecular to the behavioral—is trending away from simple dictums toward greater complexity and intricacy. Just so, stock markets are too vast and complex to be reduced to rules everyone can follow. If it were so easy, we'd all be rich.

Again, this isn't to say all reductionist thinking is bad. The true test of any theory, however, is its predictive power. A theory can be wholly logical but still not work in practice (more on this in Chapter 7). If a theory can't repeatedly forecast an outcome, it's of little value. A bit of skepticism pointed toward the grandiose claims of behavioral scientists and market gurus, and it'll be apparent how flimsy and unscientific most theories really are.

Apollo's arrow shot crooked yet again.

Chapter InSights

Because of innate human limitations and biases, we need a system that helps us be more objective about solving investing problems. Science is such a method. However, like any approach, science has its pitfalls and is no panacea.

- We need both reason and imagination to invest well—pure calculation alone cannot produce new insights.
- Science provides "grounding" for us to glean insight and gain knowledge.
- The scientific method is just that—a method. Not a dogma. It allows us to test ideas and see if they pair with reality and are repeatable.
- The difference between reality and theory is an important distinction. Theories are descriptions of the world in terms we can understand, not necessarily direct representations of reality.
  - Theories are only as good as their ability to *predict* and *describe* reality.
- The way we categorize the world says a lot about how we see the world.
  - Categories are human things, not observations about reality.
  - Often, the categories we create will influence the outcome of our experiments.
- Mathematics is not necessarily a "discovery," but one way for humans to understand the world around them.
  - Often math cannot explain much of the real world.
  - Some mathematic models, such as the VaR, have caused undue faith and contributed to financial catastrophes.
- Reduction is a feature of math and the scientific method.
  - Reduction helps us separate big problems into simple parts and jibes with the human propensity to find cause-and-effect relationships.
  - However, reductionist methods are often contrary to how complex systems, like markets and economies, work.